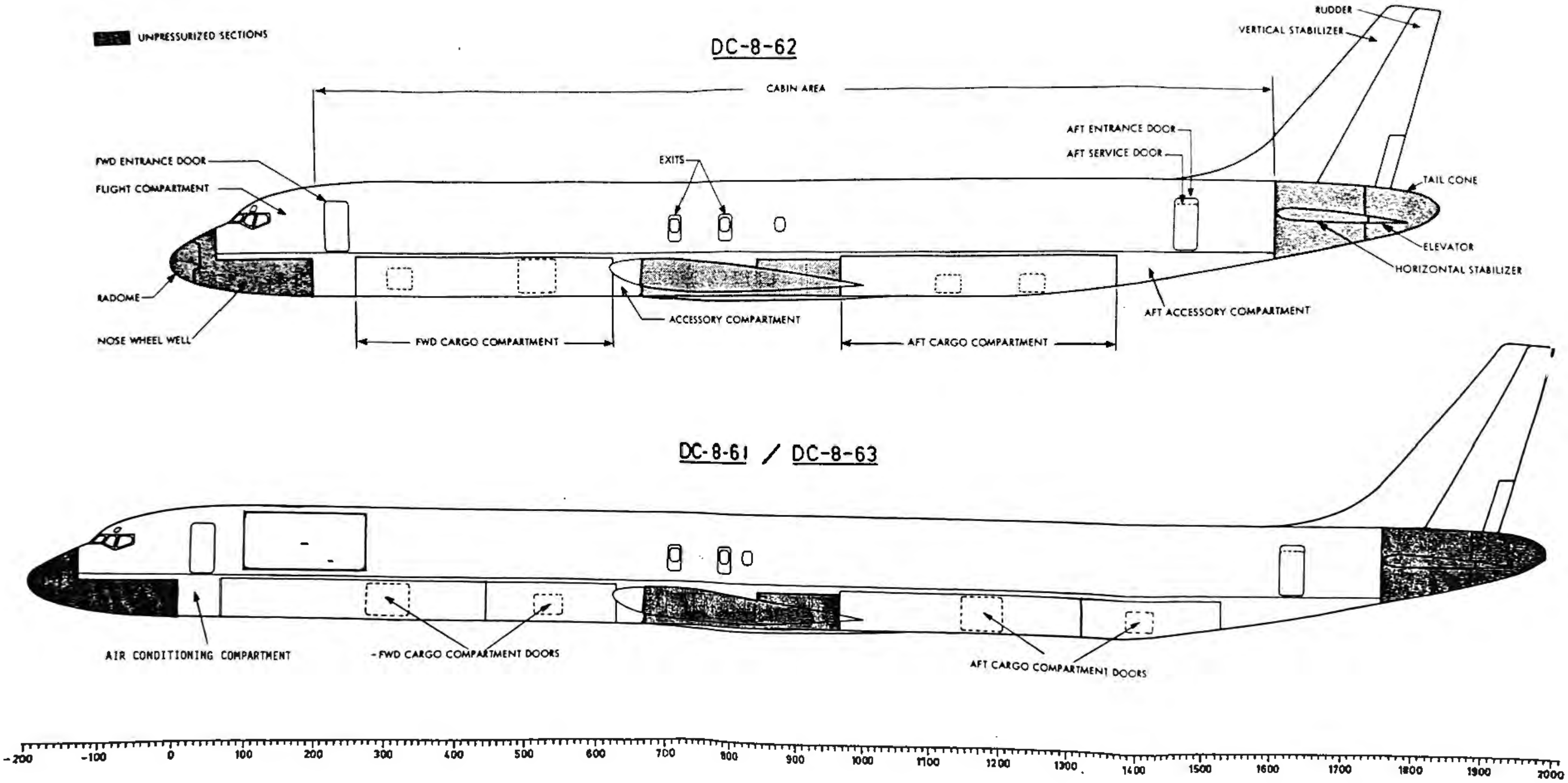
DC-8 Maintenance study guide volume 1



AIRFRAME AND INTERIOR

1. Description

The airplane structure features on all metal semimonocoque constructed fuselage, fully cantilevered swept back wing, and an empennage or tool section. The principle of fail-safe, multiple-element construction is applied. In this type of construction, the loads are distributed over a number of integral units so that flight loads may be carried safely if one member fails. Materials used are selected to provide the greatest strength, endurance or heat protection possible with the minimum amount of weight.

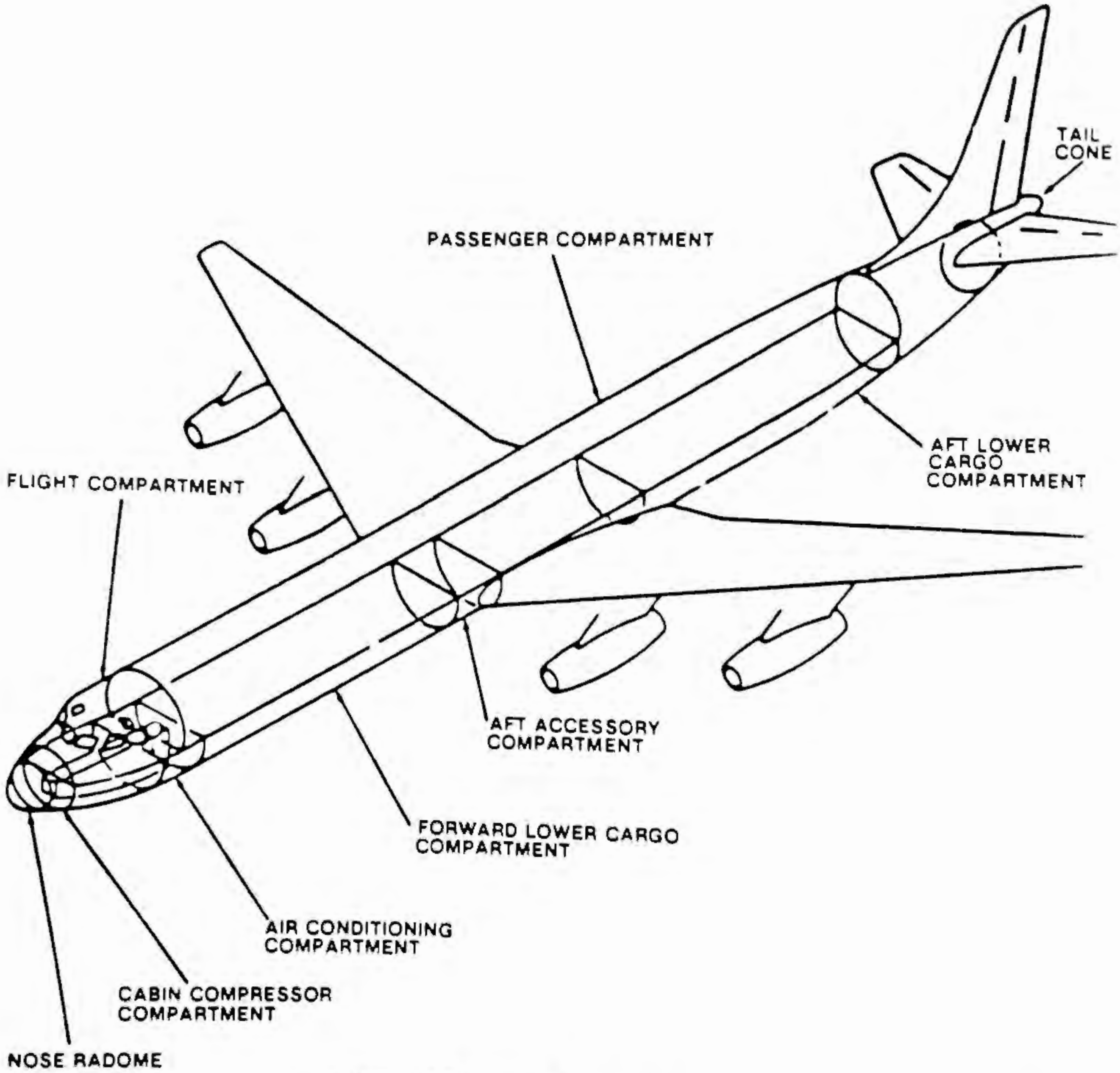
2. Fuselage Structure (See Figures 1-1, 1-2 and 1-3)

A. The fuselage is an all-metal structure, consisting of stressed aluminum alloy plating and skins attached to transverse frames and longitudinal stiffeners. It consists of a nose section, a center section, and a tail section. The nose section contains the flight compartment, the nosegear well, the cabin compressor compartment, and the air-conditioning compartment. The center section contains the upper cargo compartment, the forward and aft lower cargo compartments, the accessory compartment, and wells for the main landing gears. The tail section supports the horizontal and vertical stabilizers.

B. The main frame, which forms the primary skeleton of the airplane, is constructed of transverse frames, longitudinal stiffeners, and lateral floor beams. Except for the forward part of the nose section and the tail section, the fuselage consists of two, semi-circular, joined segments.

C. The auxiliary structure consists of the floor of the flight, upper cargo, and forward and aft lower cargo compartments, interior partitions, and blowout plugs. The floor consists of panels of various lengths and widths supported by beams, frames, and intercostals. The blowout plugs are installed in the cusp membrane along each side of the upper cargo compartment to control the airflow between the upper cargo compartment and the compartments below the floor.

D. The plating and skins that form the outside surface of the fuselage consist of panels of various lengths, widths, and thicknesses. The plating and skins are attached to the frames, longerons, and intercostals and form the primary structure of the fuselage.


TAIL CONE
PASSENGER COMPARTMENT
AFT LOWER CARGO COMPARTMENT
FLIGHT COMPARTMENT
AFT ACCESSORY COMPARTMENT
FORWARD LOWER CARGO COMPARTMENT
AIR CONDITIONING COMPARTMENT
CABIN COMPRESSOR COMPARTMENT
NOSE RADOME

FUSELAGE COMPARTMENT

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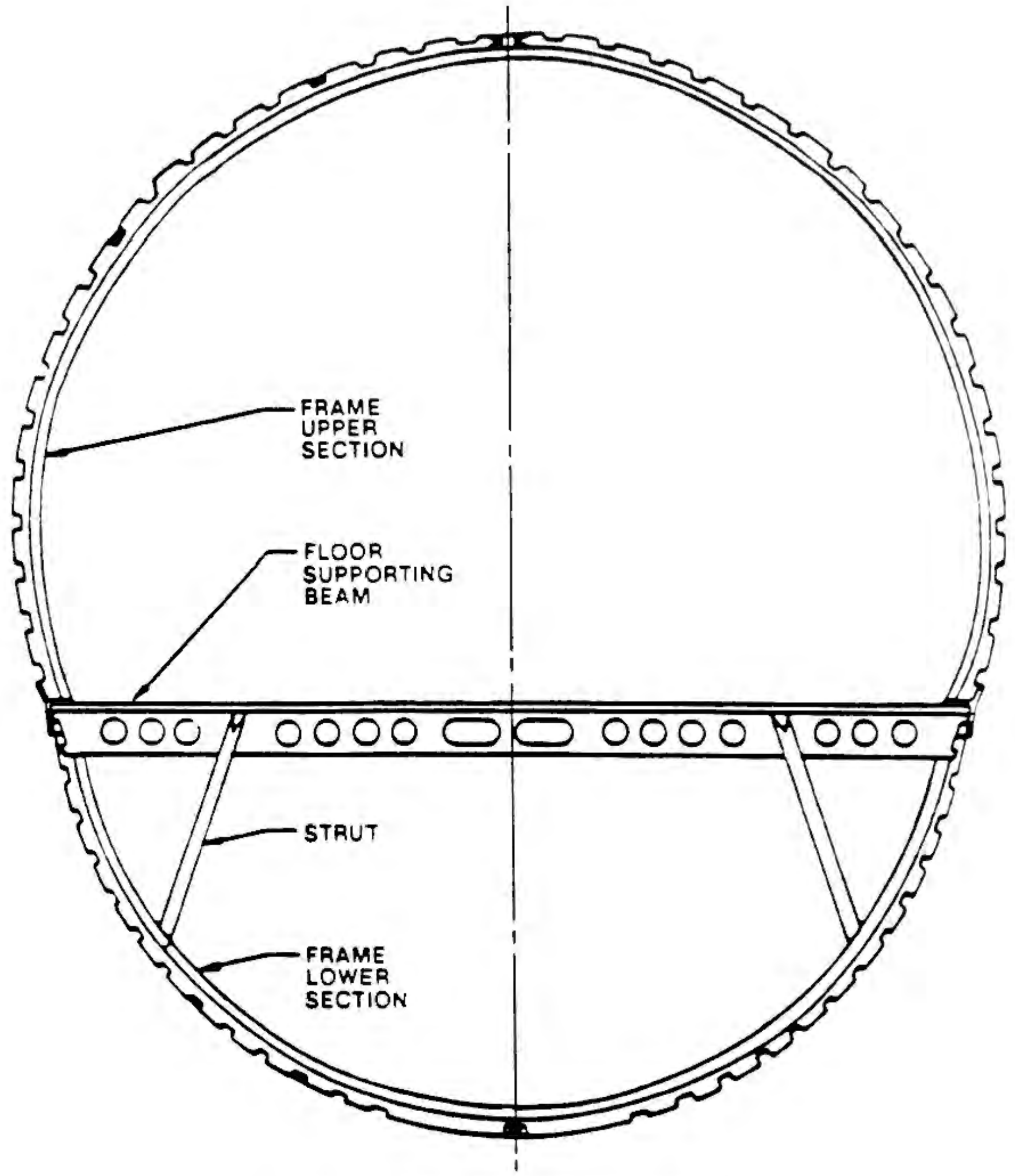
Figure 1-1



FUSELAGE CROSS SECTION

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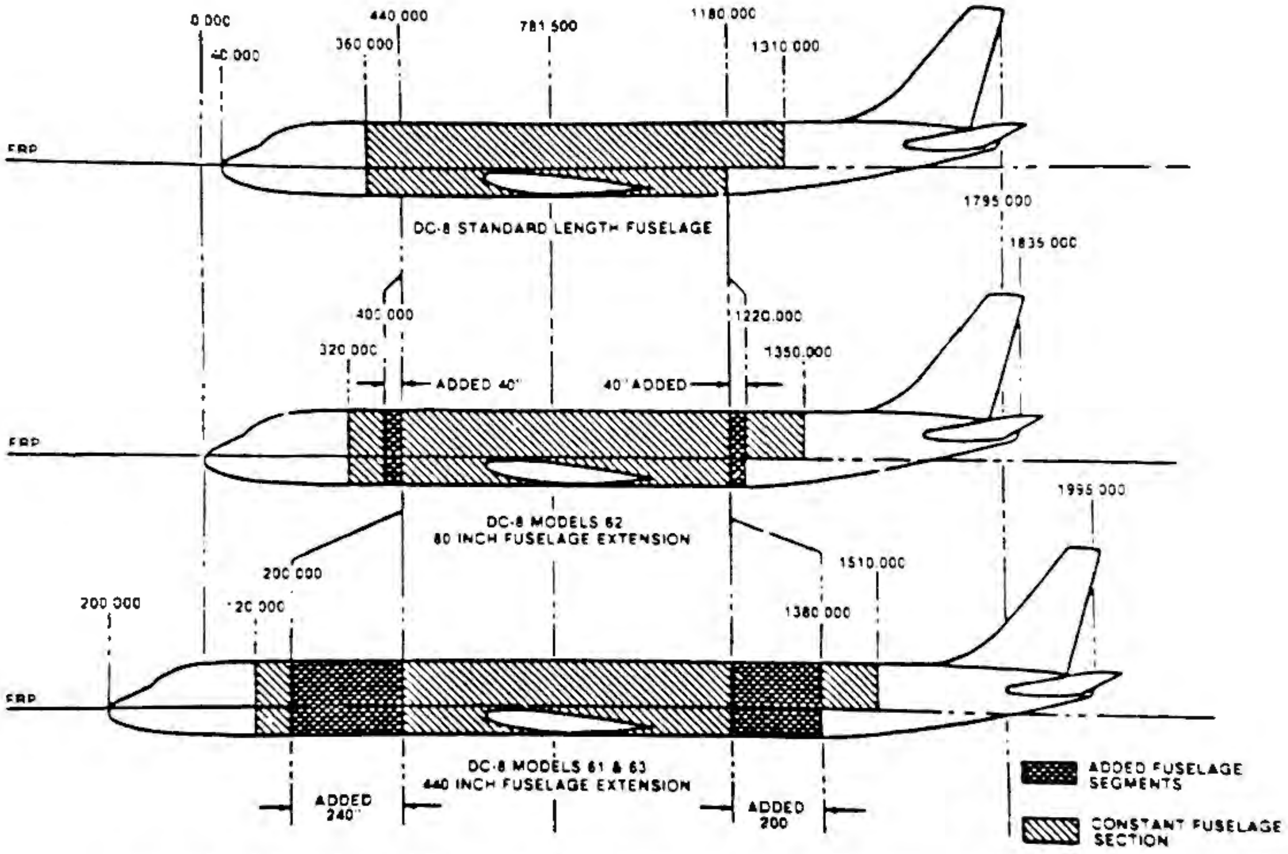
Figure 1-2



FUSELAGE COMPARISON SERIES 10 THRU 50 & 60

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Figure 1-3

E. Fittings are provided throughout the fuselage for the attachment of doors, landing gear, brackets, and supports.

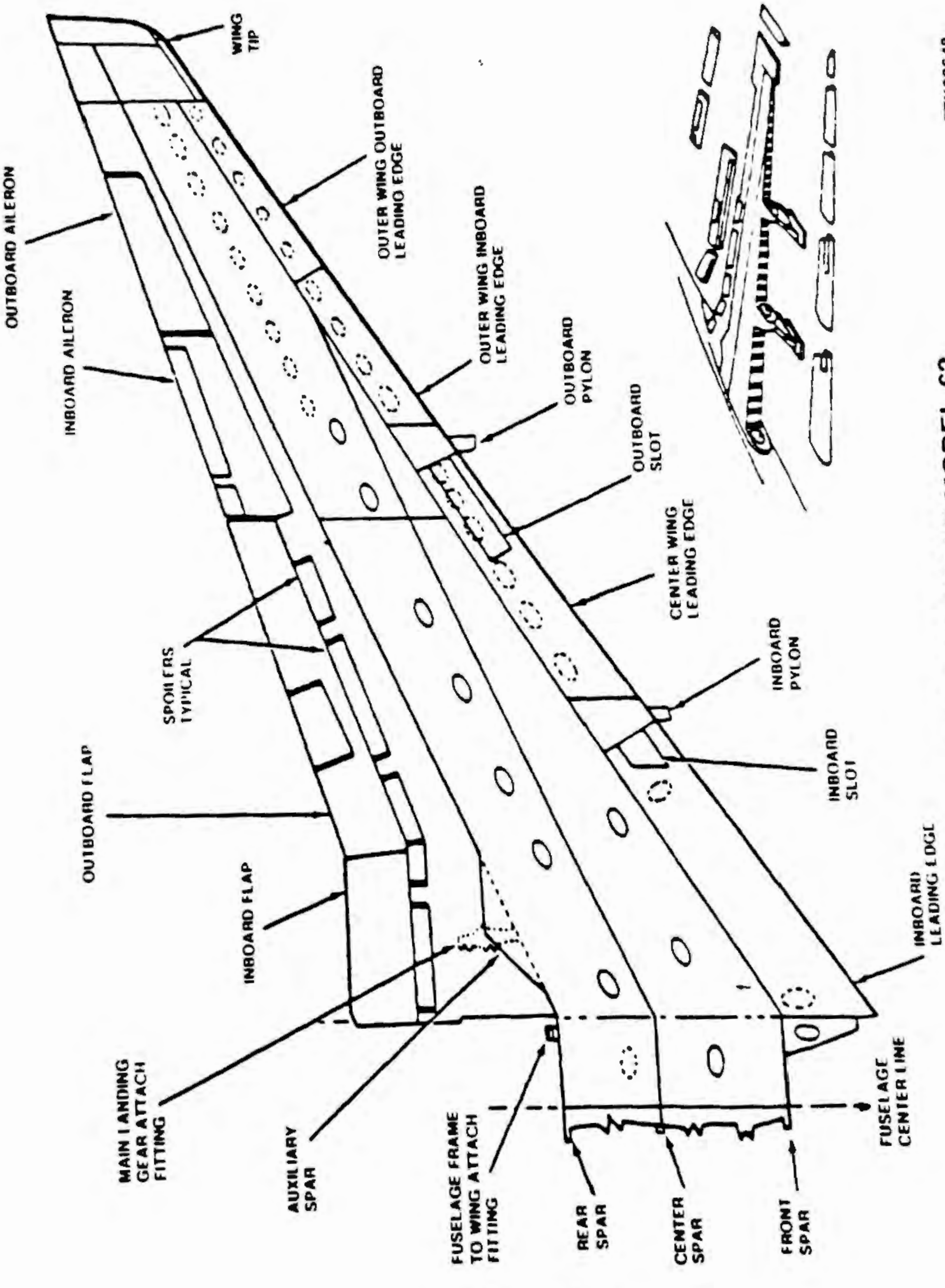
F. The cones consist of a radome installed on the forward bulkhead of the nose section and a tail cone installed on the aft end of the fuselage. The fillets are installed in the area where the wings join the fuselage. The radome protects the antenna installed on the forward bulkhead. The radome, constructed of fiberglass, is hinged at the top to the fuselage structure and secured in the closed position by latches. The tail cone is constructed of frames, angles, doublers, stiffeners, fittings, and plating. A navigation light is installed on the aft end of the tail cone. A door is provided in the lower surface of the tail cone for access to the navigation light and the elevator torque tube.

3. Wing Structure (See Figures 1-4 and 1-5)

A. The wing is an all-metal, fully cantilevered, swept back single-unit mounted through the lower fuselage. Ailerons, flaps, spoilers, leading edge slots, and the supporting structure for the attachment of the main landing gear are attached to the wing. Integral fuel tanks formed by the wing structure are protected with a corrosion protection coating.

B. Ventilation is provided within the wing structure to prevent the accumulation of fuel vapors in the leading edge, wingtip, and main landing gear area. Air inlets in the fuselage to wing fillets, leading edge near the wingtip, and in the pylons allow air to enter the wing structure. The air circulates through the leading edge and goes out two vents in the lower surface of the leading edge center section. Some of the air circulates through the wingtip and goes out vents in the wingtip lower surface. Ventilating air for the wing center section and main gear area comes from the inlet in the fuselage to wing fillet and through the trailing edge and goes out vents forward of the main gear doors. Dams with adjacent drain holes in the leading edge prevent liquids from draining into other areas.

C. The main frame is of a three-spar construction with the center spar joining the front spar outboard of the outboard pylon. Various types of ribs and bulkheads are used in the wing main frame to provide chordwise support. Liquid tight bulkheads form the integral fuel tank compartments. Bulkheads with heavy extruded cap members provide support for hinge attachments such as the aileron, spoilers and flap assemblies.



WING ASSEMBLY MODEL 62

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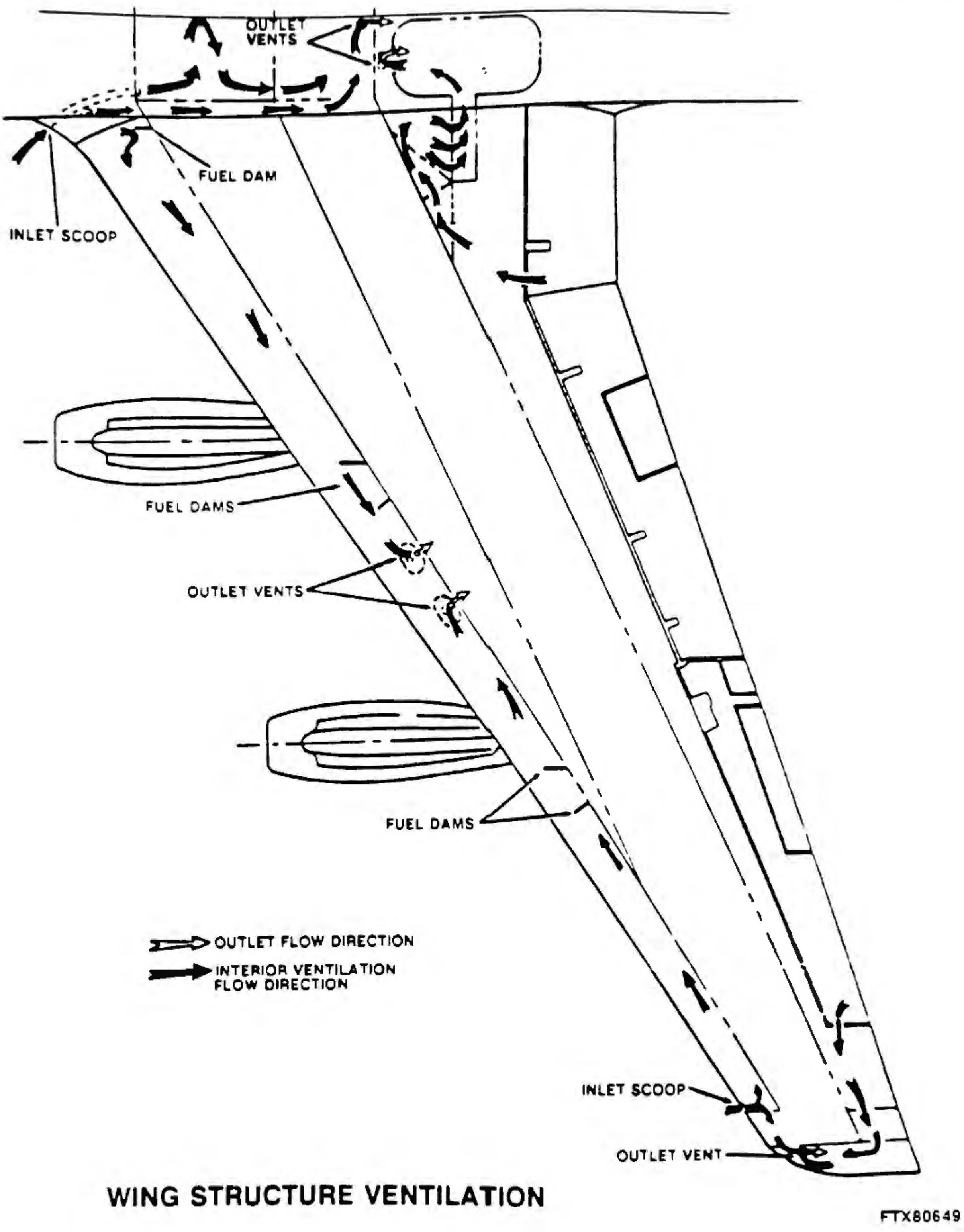
Figure 1-4



WING STRUCTURE VENTILATION

Figure 1-5

D. The auxiliary structures of the wing consists of the leading edge sections, wingtip, and trailing edge panels. Leading edge sections and wingtips are removable for maintenance.

E. The plating between the front and rear spars is tapered, butt-spliced, and flush-riveted on all external surfaces. The number of separate plates used in construction was kept to a minimum by using premium size sheets. Access doors into the fuel tank are of a stressed type to carry structural loads.

F. Flight controls attached to the wing are the ailerons, flaps, and spoilers. The ailerons and flaps are similar in construction and consists of spars, ribs, and skin with bonded doublers. Spoilers and aileron tabs are constructed of aluminum honeycomb with bonded skin.

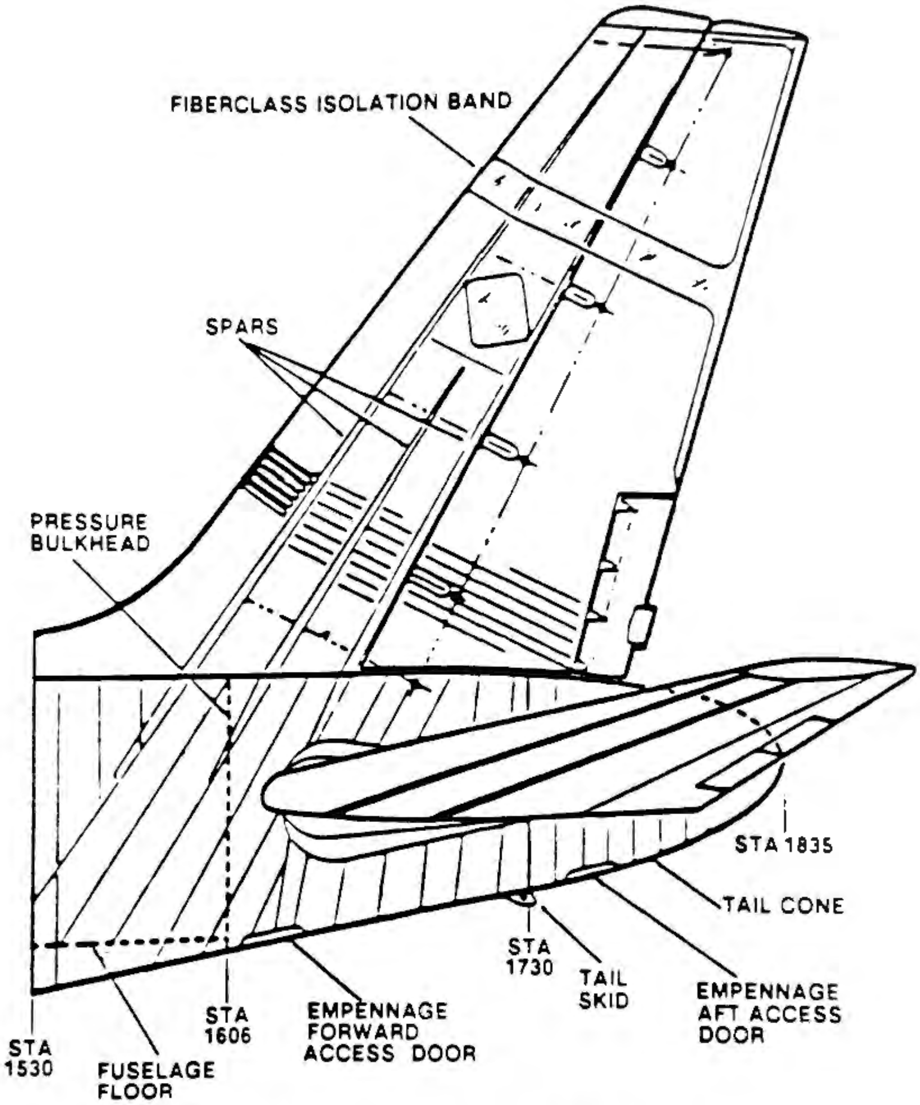
4. Empennage Structure (See Figures 1-6 and 1-7)

A. The empennage, or tail group, consists of the vertical stabilizer, horizontal stabilizer, aft fuselage and the tail cone.

B. The vertical stabilizer is a fully cantilevered, swept back single unit and is constructed as an integral part of the aft fuselage structure. It is made of three main spars employing metal covering reinforced by chordwise ribs. The spars are flat-webbed type and have extruded or formed stiffeners and caps. The upper and lower portions of the vertical stabilizer are separated by a structural laminated glass fiber isolation band. The tip section is constructed of laminated glass fiber hat stiffeners with a laminated glass fiber covering, which houses a VHF antenna.

C. The rudder is an all-metal structure except in areas requiring antenna isolation where laminated glass fiber is used. It is constructed of a spar and chordwise ribs covered with skin reinforced with bonded doublers. The rudder is hinged to brackets attached to the rear spar of the vertical stabilizer. Both the rudder and the control tab are sealed against the entry of liquids, however, drain holes are provided in areas where liquids might collect.

D. The horizontal stabilizer consists of right and left outer panels joined to an inner constant section and mounted in the aft fuselage structure. The horizontal stabilizer contains two spars, joined by chordwise ribs and spanwise stiffeners covered by integrally stiffened machined panels be-



EMPENNAGE - DC-8-62/62F

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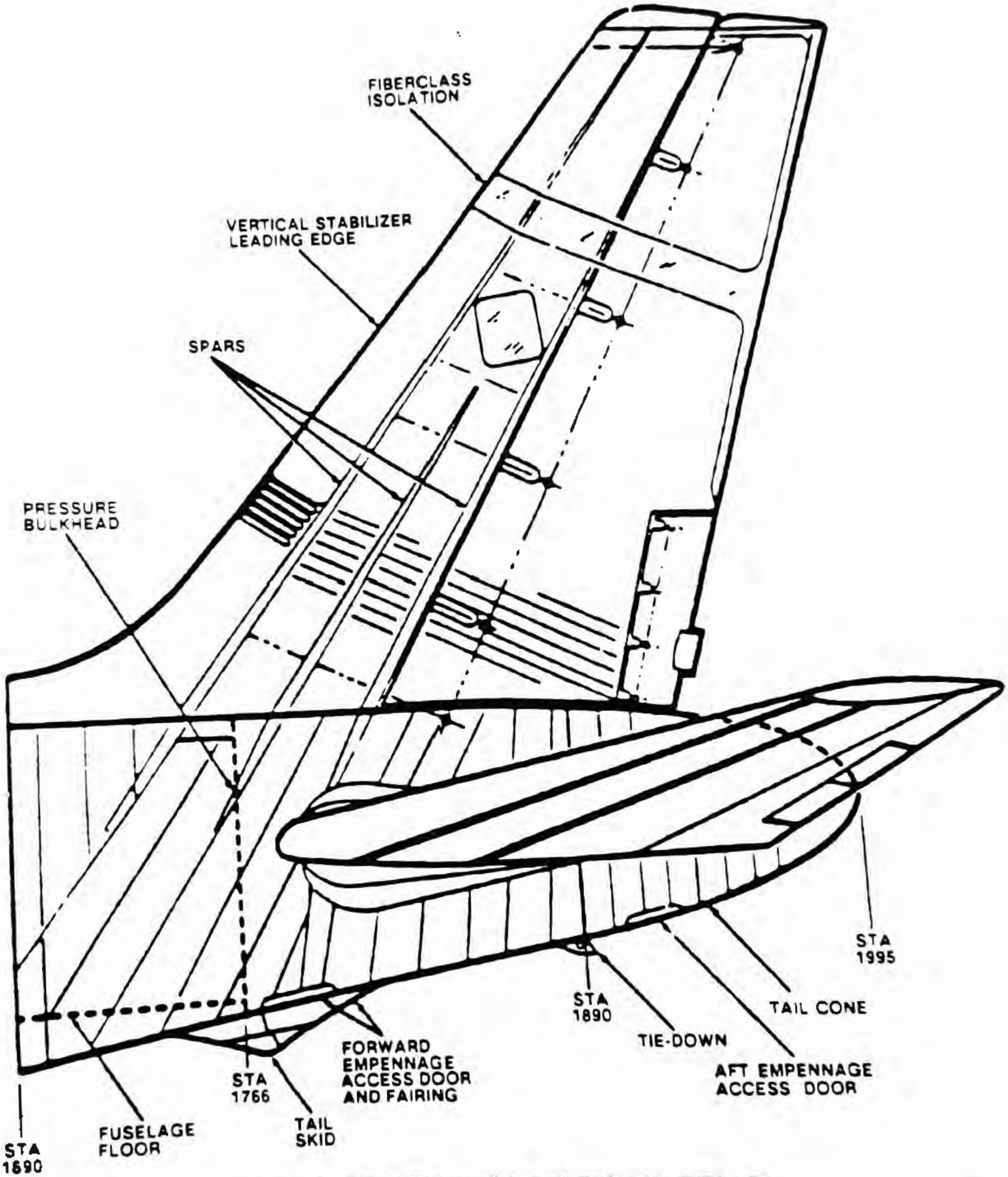
Figure 1-6



FUSELAGE TAIL SECTION-MODEL 61

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Figure 1-7

tween the spars. The spars are flat-webbed type having caps, extruded or formed stiffeners, and webs. The leading edge of each outer panel has a double skin for thermal deicing.

E. The elevators consist of a left panel and right panel, interconnected and hinged to brackets attached to the rear spar of the horizontal stabilizer. The elevators are of all-metal construction with ribs and skins reinforced with bonded doublers. The elevators are sealed to prevent entry of liquids and excessive circulation of air, however, they are provided with drain holes in areas where liquids might collect. Roller bearing hinges are incorporated and the bearings may be replaced without removing the elevator.

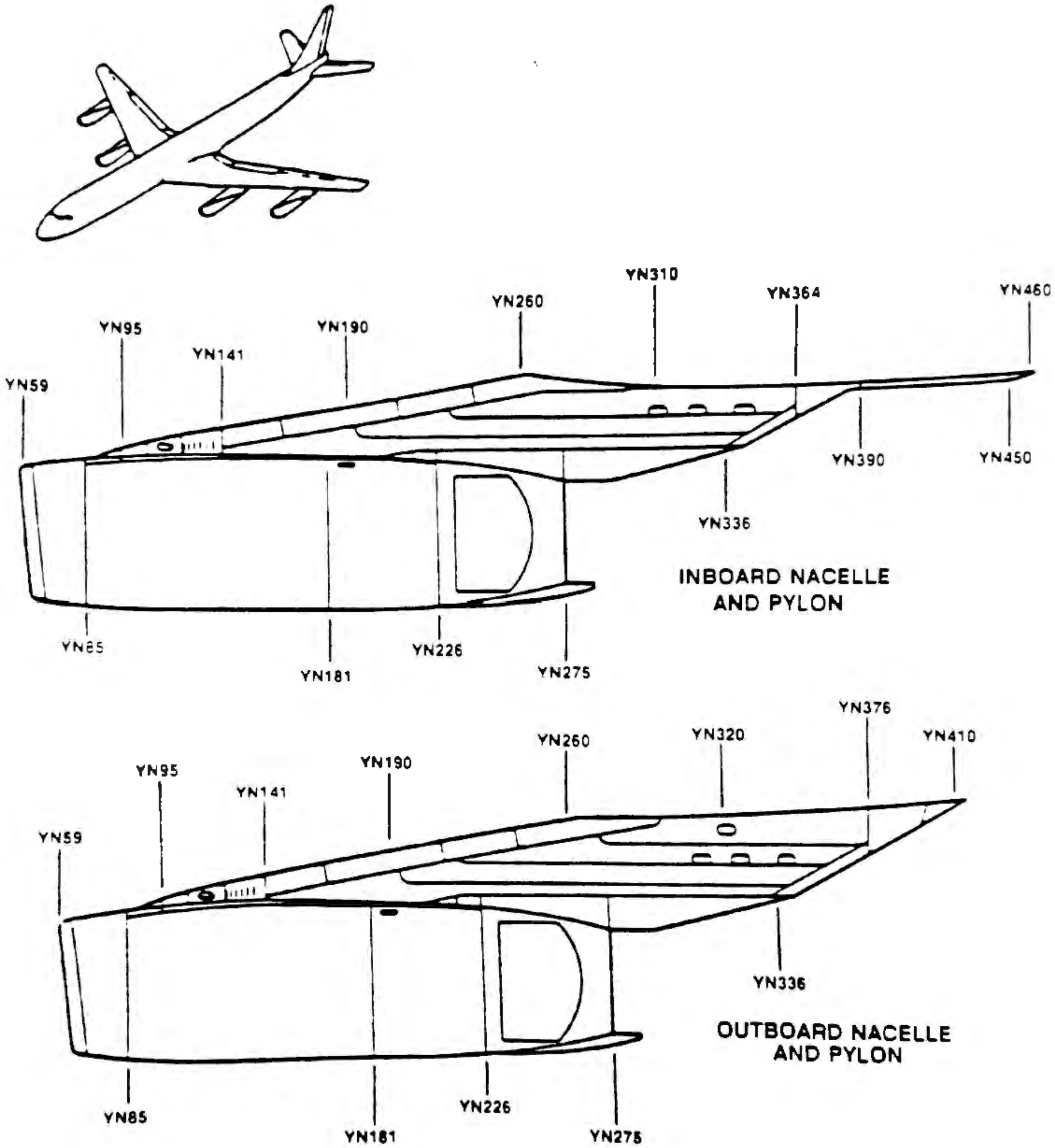
F. Control tabs, of all-metal construction, are incorporated in the trailing edge of each elevator. The tabs are sealed to prevent the entry of liquids. The control tabs are interchangeable without the necessity of rebalancing the elevator. A geared tab is hinged to the trailing edge of each elevator, outboard of the control tab. The geared tab is interchangeable without rebalancing the elevator.

5. Nacelles/Pylons (See Figures 1-8 and 1-9)

A. Pylon structures, two on each wing, suspend and support the demountable power plant and components. They are cantilevered forward and downward from the wing to which they are permanently attached. The power plants are housed within cowl-type doors and pylon aprons. Pylon aprons are permanently attached to the pylon, but cowl doors are removable.

B. Each pylon consists of a main frame, auxiliary structures, and attach fittings. Construction of the main frame for the outboard and inboard pylons is identical except for wing affected dimensions. Principal structural loads of the pylon are carried by heavy side planks. These planks are milled from solid aluminum material for maximum strength. The pylon auxiliary structures are the leading edge sections and the trailing edge section. Each engine is supported by mounts within the pylon structure, one forward and one aft.

C. The pylon is constructed to provide maximum fire protection. The main horizontal firewall is in two sections extending from the forward accessory compartment to the trailing edge. This firewall is constructed of titanium. The forward engine mount bulkhead is constructed of stainless steel and serves as a firewall. The aft engine mount bulkhead is constructed of



NACELLES AND PYLONS - DC-8 MODEL 62

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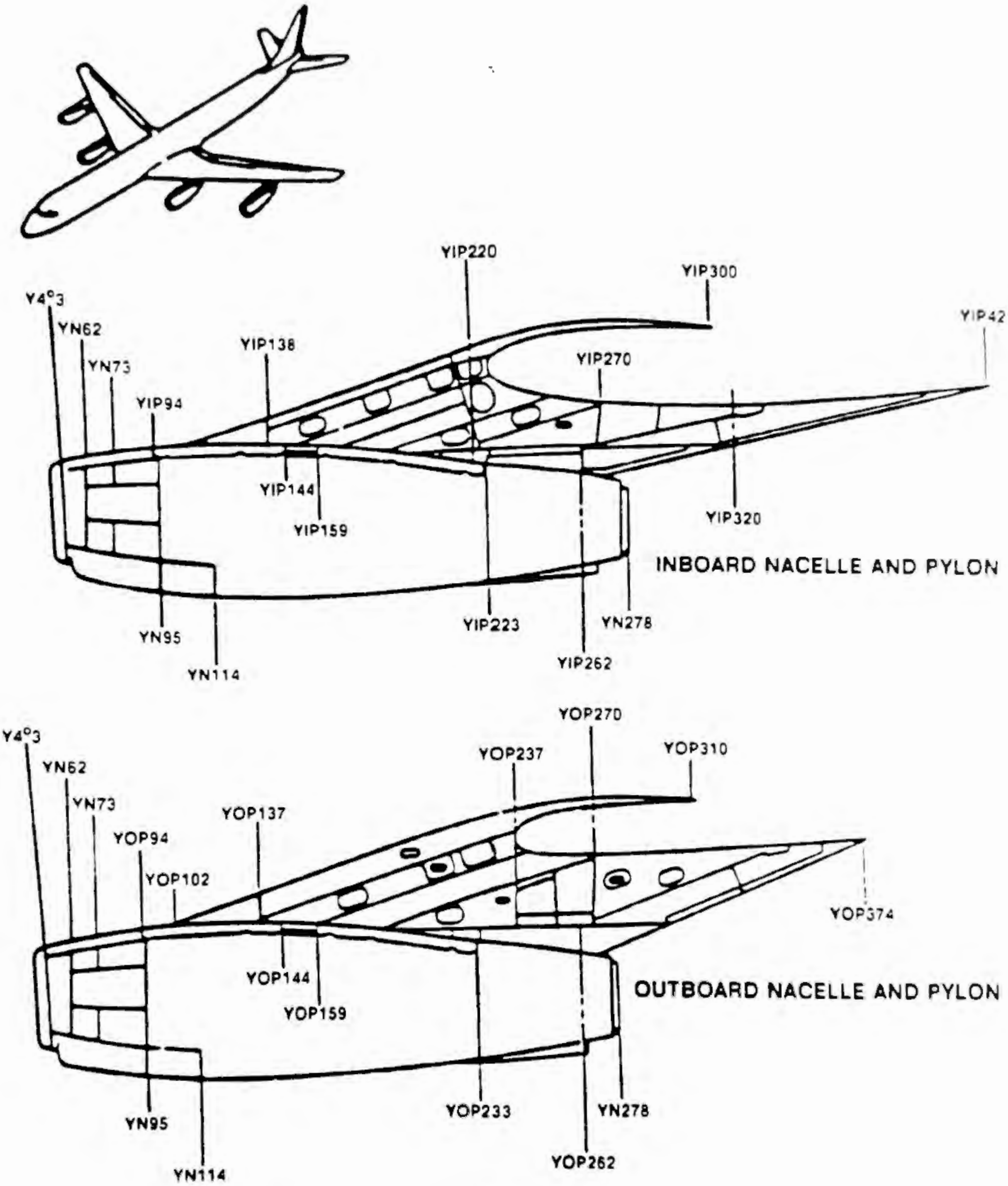
Figure 1-8



PYLON STATION IDENTIFICATION

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Figure 1-9

titanium and is considered a fireseal. A compartment ventilation barrier extends from the bulkhead at station Y_n 166 to the aft engine mount bulkhead.

D. The following text defines terminology used to describe various bulkheads in the structure of the pylon.

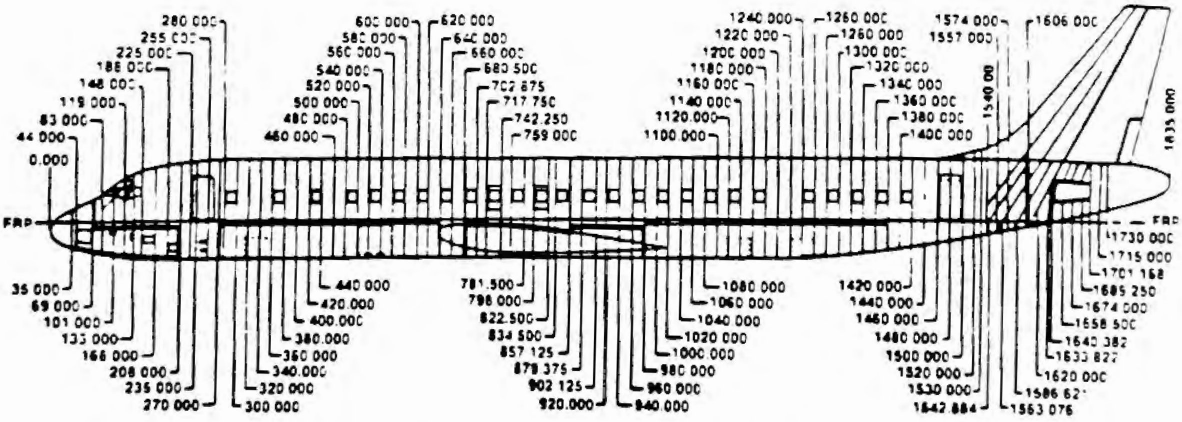
(1) Fireproof - Aircraft structure and components that are designed to perform their design function for 15 minutes when subjected to a flame of 1093 (±10)°C (2000 (±50) °F). Specifically, these bulkheads are made from steel or titanium of sufficient dimension to withstand the most severe conditions of fire likely to occur in the area where used.

(2) Firewall - A boundary intended to isolate a fire in its place of origin and prevent the fire from spreading to adjoining sections. The boundary is made of fireproof material, either steel or titanium of 0.015-inch minimum thickness, and is constructed to prevent the passage of vapor, fluid, or flame. Ducts, tubing, and control cables passing through the firewall are constructed of similar materials and will prevent similar conditions.

(3) Fireseal - A boundary that serves essentially the same purpose as a firewall but offers a lesser degree of protection. A fireseal can be used to isolate a zone of secondary protection from sections of the airplane other than fire zones. Fireseals are used in place of firewalls where the installation does not need to be vapor tight. Replaceable collars of flexible asbestos material may be substituted for bulkhead fittings for piping.

(4) Vapor Seal - A boundary used to isolate a possible ignition source from a compartment containing combustible fluid or vapor such as fuel or hydraulic lines. A vapor seal bulkhead is vapor tight and liquid tight but might not be fireproof.

E. Adequate access doors are strategically located to afford access to components within the pylon for servicing, replacement, and inspection of the pylon structure. These doors vary in size, type, attachment, and method of opening. Normal visual inspection techniques using a mirror and flashlight through the access doors are considered adequate to verify structural integrity. Pneumatic ducts, electrical and mechanical controls are routed on top of the upper spar. Fluid lines and hydraulic lines are located between the upper and lower spars.



FUSELAGE STATION NUMBERING DIAGRAM

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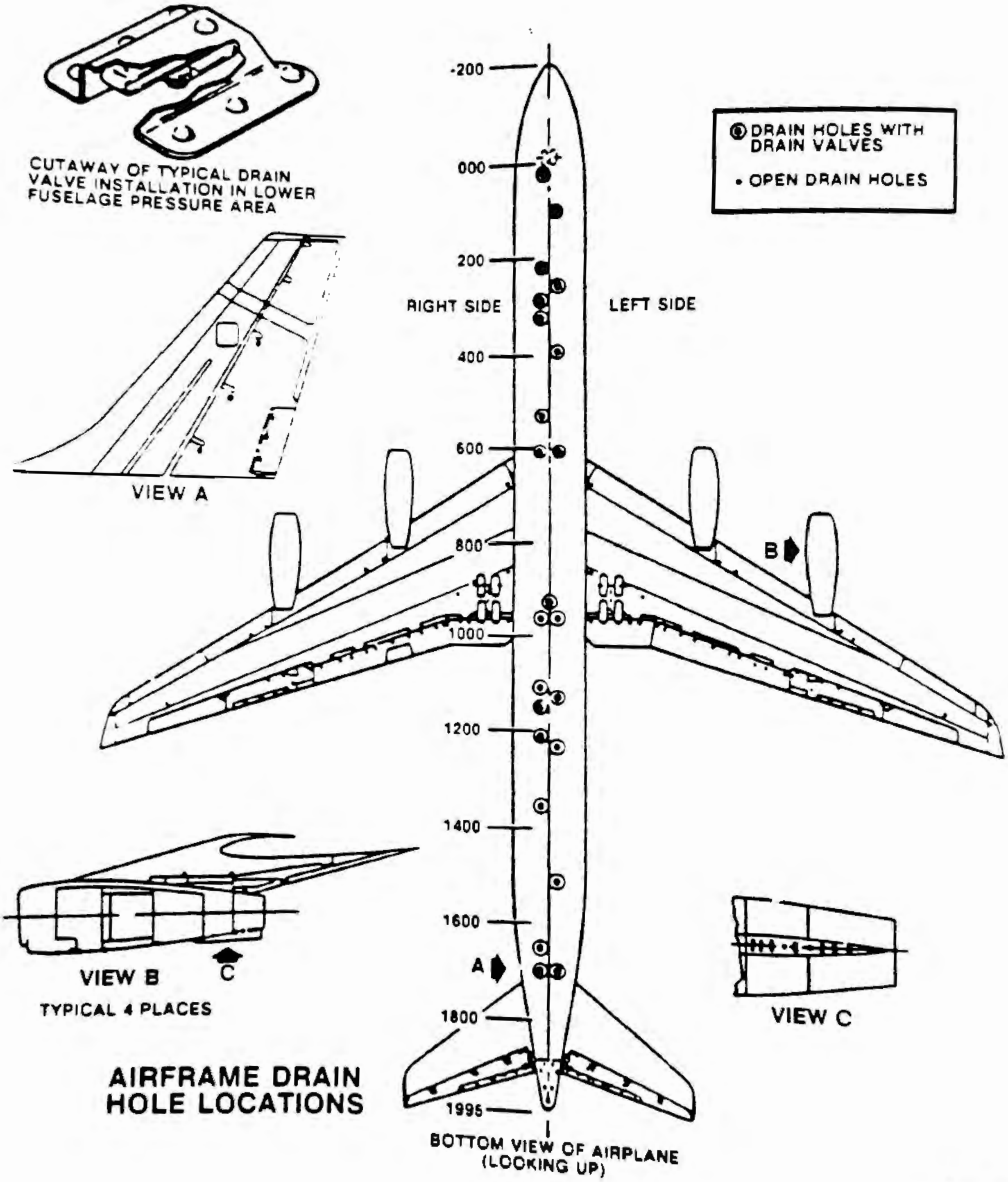
Figure 1-10


CUTAWAY OF TYPICAL DRAIN VALVE INSTALLATION IN LOWER FUSELAGE PRESSURE AREA
VIEW A
VIEW B
C
TYPICAL 4 PLACES
AIRFRAME DRAIN HOLE LOCATIONS
-200
000
200
400
600
800
1000
1200
1400
1600
1800
1995
RIGHT SIDE
LEFT SIDE
A
B
DRAIN HOLES WITH DRAIN VALVES
• OPEN DRAIN HOLES
VIEW C
BOTTOM VIEW OF AIRPLANE (LOOKING UP)

FTX80656

Figure 1-11

6. Windows - Description

Three basic categories of windows are installed: the flight compartment windows, the emergency exit hatch windows, and the entrance and service door windows.

7. Flight Compartment Windows (See Figure 1-12)

A. The flight compartment contains five different types of windows; a center windshield and two side windshields, a clearview window on either side, an aft window on either side, and two upper windows immediately above the clearview windows.

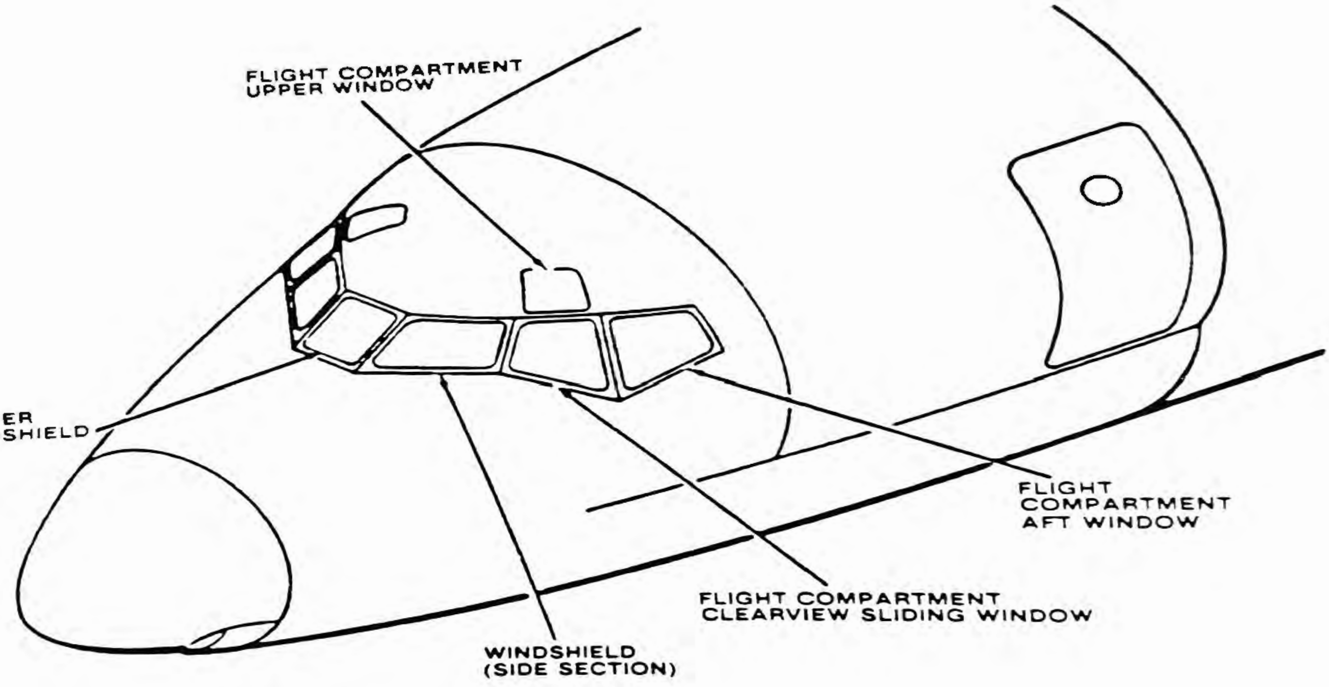
B. Center and Side Windshields

(1) The center and side windshields are laminated panels and are mounted from outside the flight compartment. The panels are constructed with an outer pane of tempered glass 3/16-inch thick, a vinyl layer 3/8-inch thick, a pane of tempered glass 1/2-inch thick, a vinyl layer of 5/64-inch thick, and an inner pane of tempered glass 3/16-inch thick.

(2) The vinyl interlayer provides greater flexing stress and impact strength to the laminated panels. The inside surface of the outer pane has a thin, transparent, electrically conductive film for anti-icing. The inside surface of the inner pane has the electrically conductive film for anti-fogging. Current passing through the conductive film heats the vinyl for greater impact resistance. The electrically generated heating of the panel is controlled by a sensor unit embedded in the vinyl interlayer. A second sensor is embedded in the vinyl interlayer to act as a spare should the first one fail. A single switch energizes the windshield heating and anti-fogging system.

C. Clearview Windows (See Figures 1-13 and 1-14)

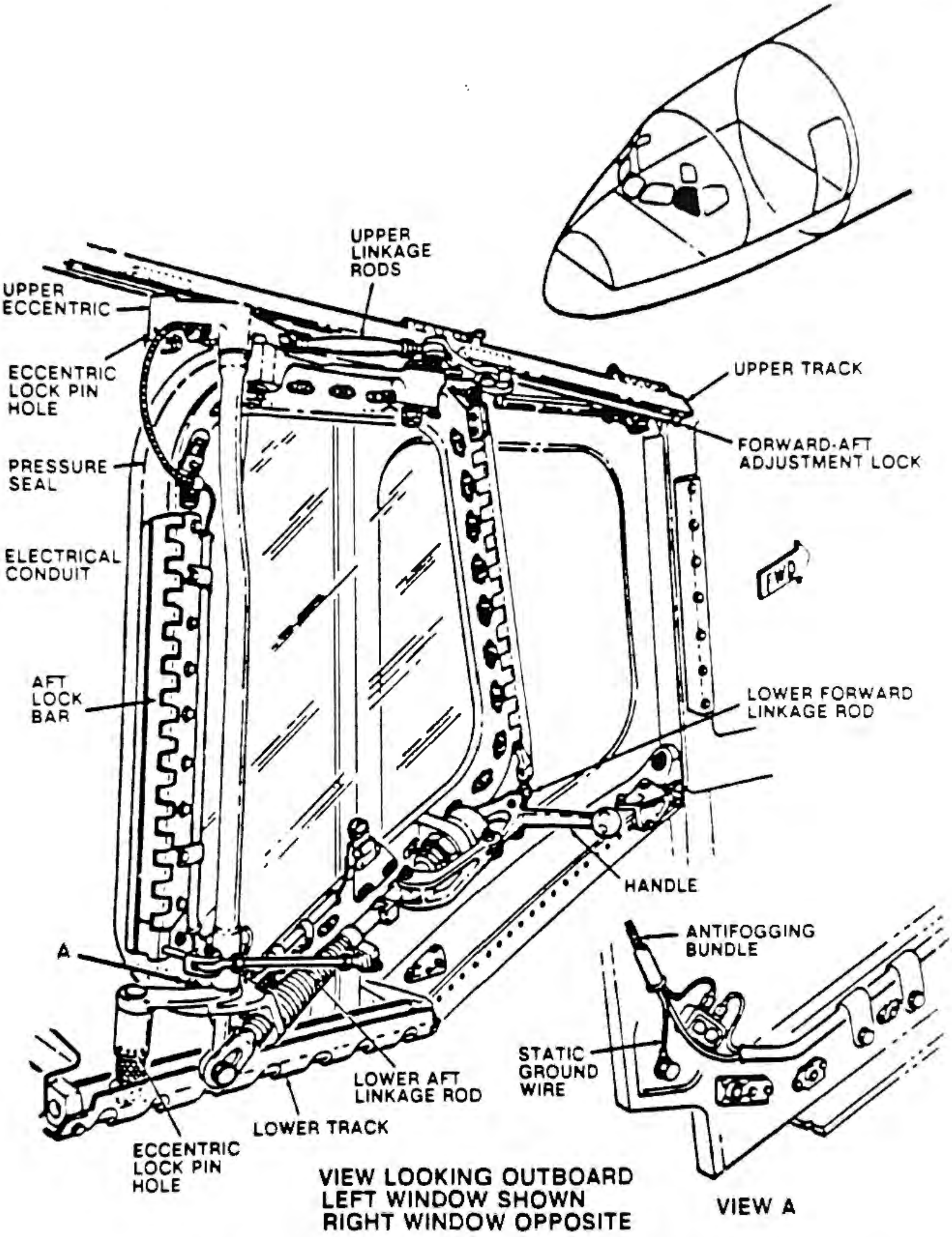
(1) Two clearview windows are located aft of the windshield side sections and below the upper windows on the right and left sides of the airplane. When the airplane is unpressurized, these windows can be opened; thus, the name clearview.


FLIGHT COMPARTMENT UPPER WINDOW
CENTER WINDSHIELD
FLIGHT COMPARTMENT AFT WINDOW
FLIGHT COMPARTMENT CLEARVIEW SLIDING WINDOW
WINDSHIELD (SIDE SECTION)

FLIGHT COMPARTMENT WINDOWS

FTX80789

Figure 1-12



CLEARVIEW WINDOW INSTALLATION

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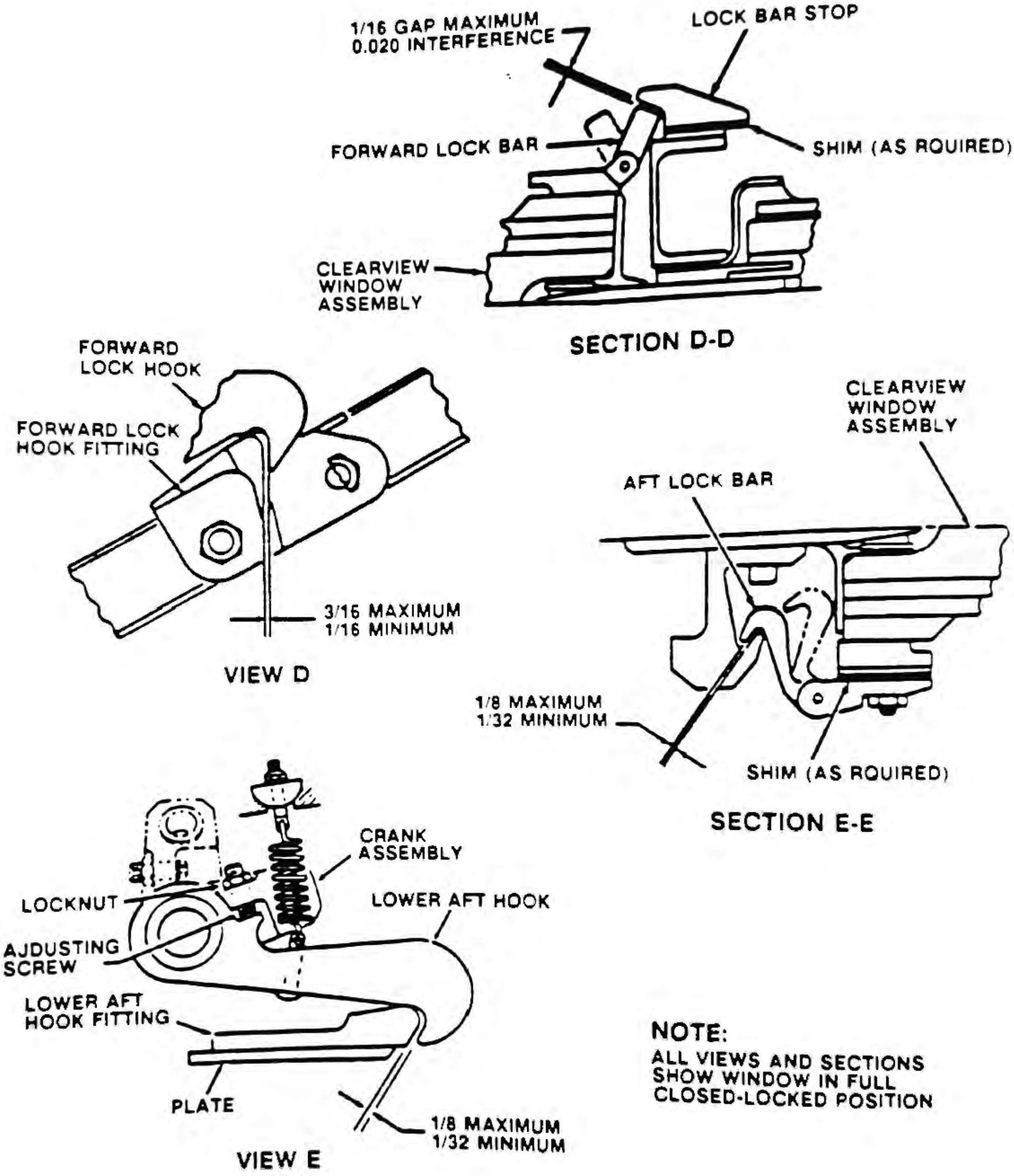
Figure 1-13



NOTE:
ALL VIEWS AND SECTIONS SHOW WINDOW IN FULL CLOSED-LOCKED POSITION

CLEARVIEW COMPARTMENT CLEARVIEW WINDOW

Figure 1-14

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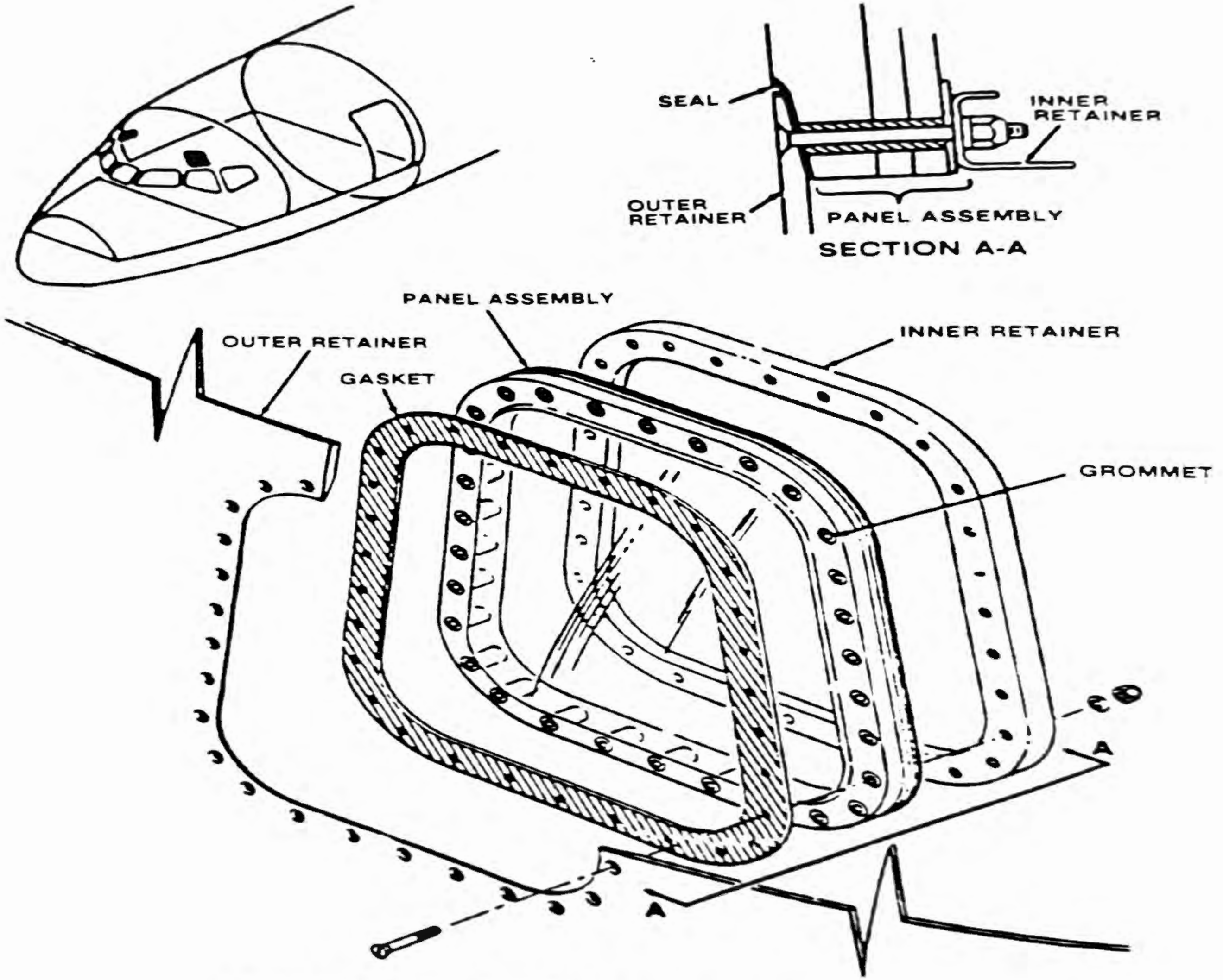
(2) The clearview window is a laminated panel consisting of two panes of stretched acrylic plastic, separated by a layer of vinyl. The panel is constructed with the outer pane 3/4-inch thick, a vinyl layer 1/8-inch thick, and the inner pane 1/8-inch thick. The windows are laminated to provide a fail-safe construction and for electrical resistance heating A thin, transparent, electrically conductive film is on the inside surface of the inner panel. Electric current passing through the conductive film anti-fogs the window and heats the vinyl to improve the plasticity for greater impact resistance.

(3) An overcenter, positive locking mechanism is actuated by moving a single handle at the forward bottom edge of each window. An aft pull on the handle disengages the overcenter lock. An inboard pull moves the window inboard. Another aft pull on the handle allows the window to slide along on tracks at the top and bottom edges of the window to an open locked position. A pressure and weather seal around the edges of the window contacts the adjacent structure when the window is closed and locked.

D. Upper Windows (See Figure 1-15)

(1) The upper windows, located immediately above the clearview windows, provide approximately 30 degrees of upward vision in level flight and improved lateral vision to the horizon during left and right turns.

(2) The upper window is a laminated panel consisting of two panes of stretched acrylic plexiglass, separated by a layer of vinyl. The panel is constructed with the outer pane 3/4-inch thick, a vinyl layer 1/4-inch thick, and an inner pane 3/16-inch thick. The vinyl interlayer provides greater flexing stress and impact strength to the panel. A thin, transparent, electrically conductive film of a metallic oxide is on the inside surface of the inner pane. Electric current passing through the metallic coated pane defogs the window and heats the vinyl to improve the plasticity for greater impact resistance.



FLIGHT COMPARTMENT UPPER WINDOW

Figure 1-15

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E. Aft Windows (See Figure 1-16)

Two aft windows are located to the rear of the clearview windows. These windows consist of two panes of acrylic plastic separated by a spacer to provide an airspace. Both panes are contoured, stretched acrylic with the outer pane 11/16-inch thick and the inner pane 17/32-inch thick. Each pane is designed to withstand maximum cabin pressure loads. The windows are bolted to a machined aluminum alloy doubler which is riveted to the flight compartment support posts, skin, and plating. These windows provide downward and aft vision.

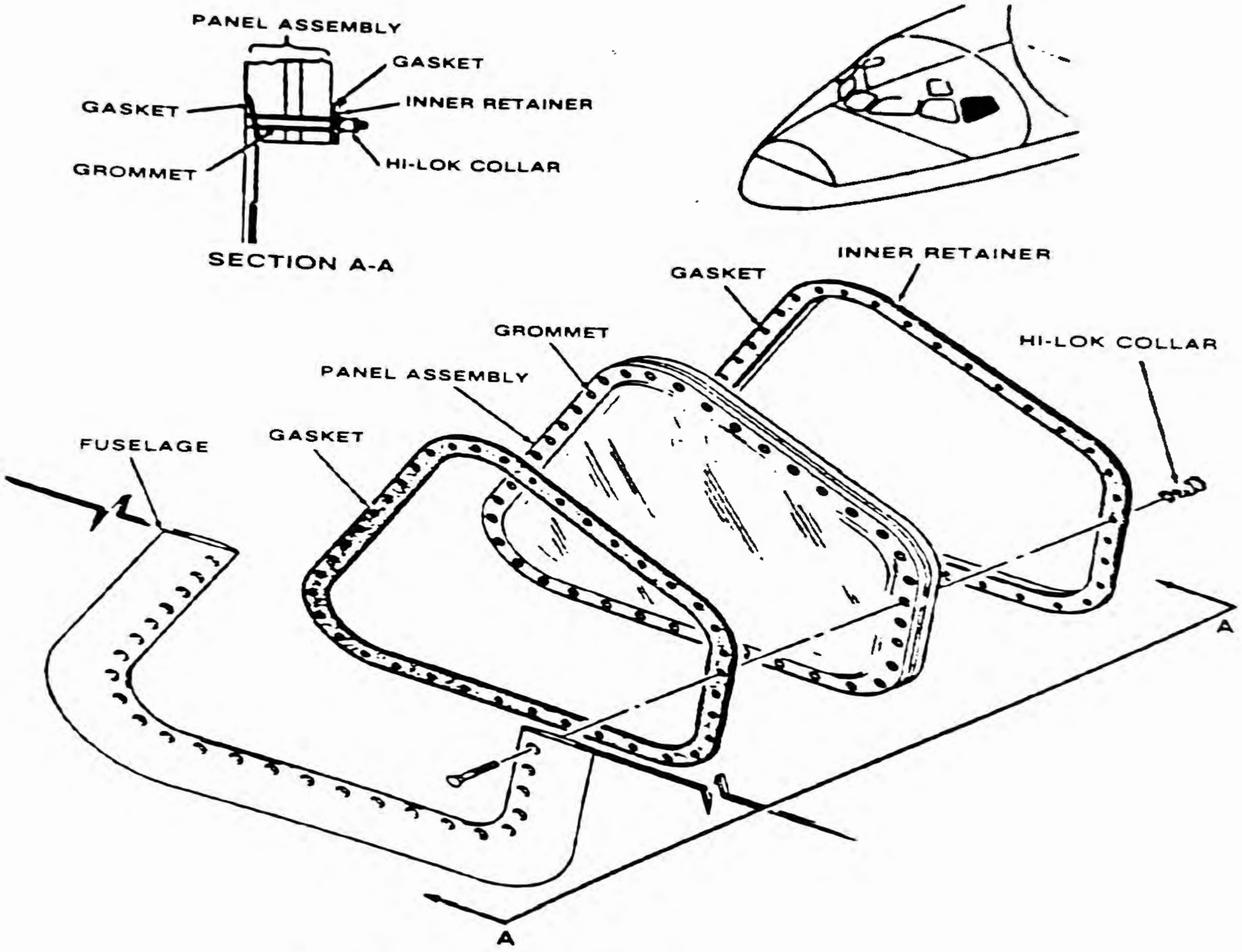
8. Overwing Emergency Exit Door Windows

A. The four overwing emergency exit doors have a viewing area of approximately 14 inches wide by 18-1/2 inches high.

B. The window assemblies are of paneled plexiglass construction. The outer panel assembly consists of two single panes of plexiglass separated by a 1/8-inch spacer. Each pane is designed to withstand the cabin operating differential pressure.

C. The outer panel is secured with flush-head, socket-shank bolts to an aluminum alloy doubler attached to the door frames. These are special bolts which have a recessed hex head internal wrenching socket in the threaded end so that it is unnecessary to hold the bolthead while tightening the nut.

D. The outer panel is 17/32-inch plexiglass material and the inner pane is 5/16-inch plexiglass. The outer panel assembly weighs approximately 15 pounds.



FLIGHT COMPARTMENT AFT WINDOW

Figure 1-16

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9. Entrance and Service Door Windows

A. Entrance and service door windows are circular in shape and are approximately 8 inches in diameter.

B. Both panes are of acrylic material; the outer pane is 3/8-inch thick and the inner pane is 1/4-inch thick. The panes are separated by a 1/8-inch spacer. The window panel is bolted to an aluminum alloy doubler.

C. A third pane for frost prevention purposes is an integral part of the door trim panel and has a foam rubber bumper around the edge. The window frame is pan recessed to allow for wide angle vision outside the airplane.

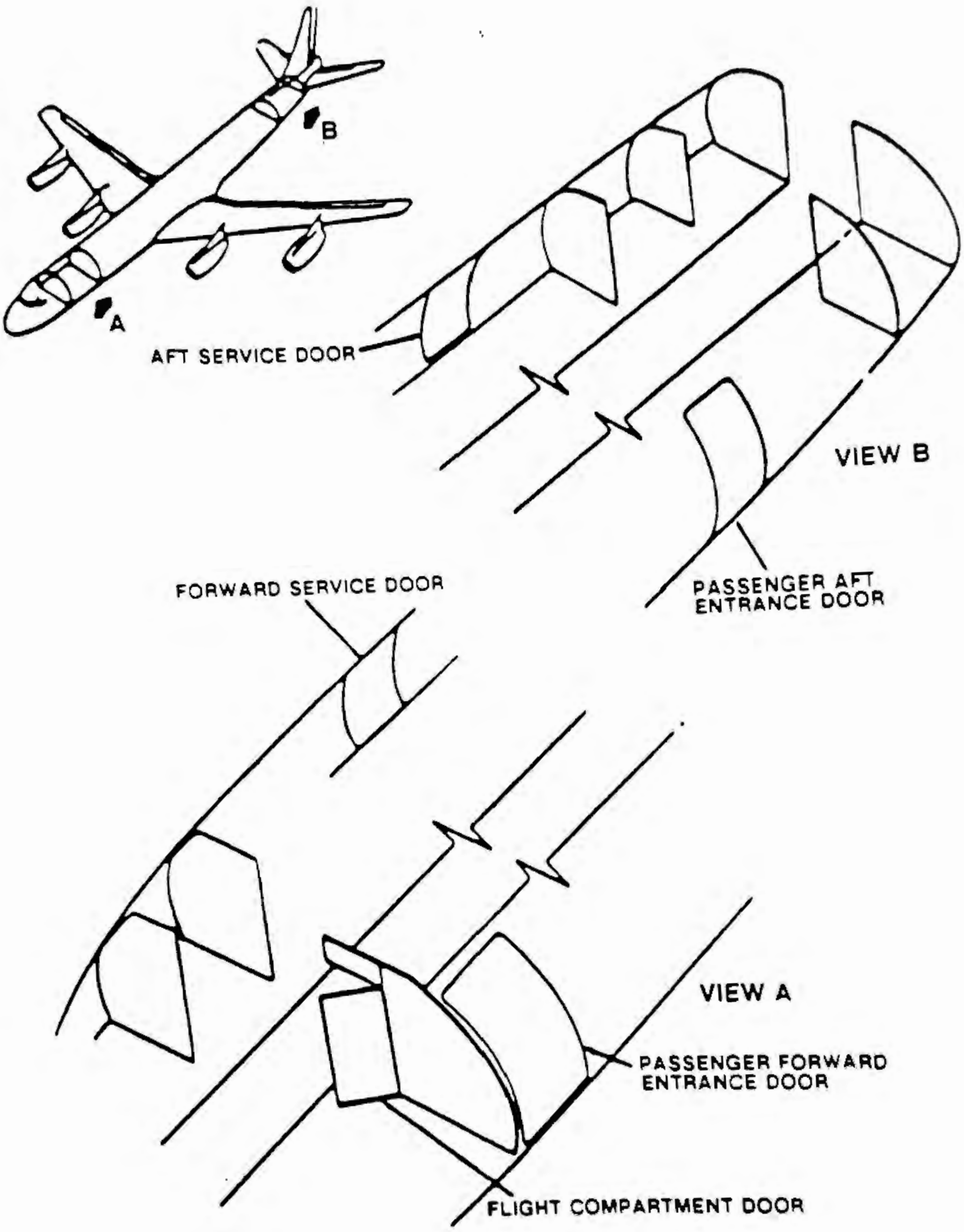
10. Doors - Description

A. Doors are provided for the cabin compartment, forward and aft lower cargo compartments, forward upper cargo compartment, air conditioning and accessory compartments, and the flight compartment.

B. All the exterior doors except the upper cargo door, and the Type I emergency exit doors, are of the plug-type. Each exterior door is provided with a pressure seal that is depressed by a seal depressor installed on the doorjamb of the door. The latching mechanisms of the exterior doors prevent the doors from opening inward as a result of external loads before pressurization. A lining is installed on the inner surface of the exterior doors.

11. Cabin/Crew Doors (See Figure 1-17)

The doors are provided for personnel and cargo to enter and leave the cabin compartment. The doors are located on the left side of the fuselage, one at the forward end of the cabin compartment and one at the aft end. The doors are similar in construction and operation. They can be opened from inside or outside the airplane by handles attached to a common shaft of the latching mechanism. A hold-open hook is provided for each door to hold the door in the open position against the outer surface of the fuselage. A window is furnished in the upper section of each door to permit a view of the area adjacent to the door. A snubber, installed in the doorjamb of each door, to protect against either wind gusts or personnel slamming the door against the fuselage or doorjamb.



INTERIOR DOORS

FTX80657

Figure 1-17

12. Emergency Exit Doors (See Figure 1-18)

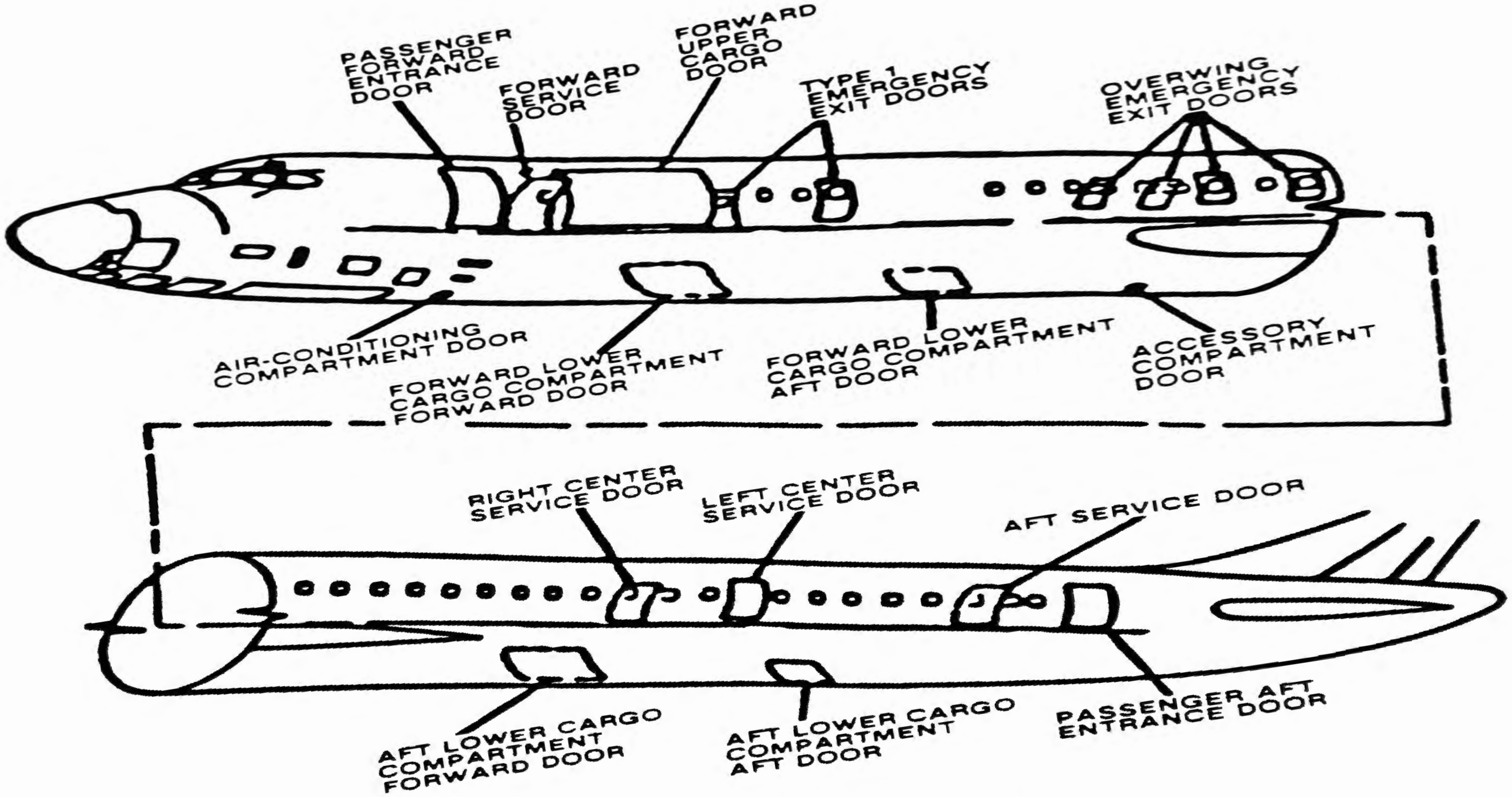
A. The number and location of the Type I emergency exit doors is dependent upon the configuration of the airplane. The Type I emergency doors are installed on each side of the fuselage at the forward and aft section of the cargo compartment. The Type I emergency exit doors have been deactivated. The door snubber mechanism, snubber cable, and the inboard snubber cable, pulley assembly and hardware have been removed, and have been replaced with two bolts and a cable assembly that attach from the door frame to the aircraft structure. Although the Type I emergency exit doors have been deactivated, they are still operable and by unbolting and removing the cable assembly, the doors open outward and downward on hinges attached to the doorjamb and the lower edge of the door. The door can only be opened from inside the airplane, by handles attached to the latching mechanism. The doors are secured in the closed position by fittings installed on the forward and aft edge of the doors, that engage stops on the doorjambs and by hooks on the upper edge of the doors, that engage the latching mechanism, and by two bolts and a cable assembly attached from the door frame to the aircraft structure.

CAUTION: TWO PERSONS ARE REQUIRED FOR THE REMOVAL OF TYPE I EMERGENCY EXIT DOORS.

B. The type III emergency exit doors are installed, two on each side of the fuselage, in the over-the-wing area. The Type III door is secured at the bottom by a lockplate, which engages a stop on the doorjamb. The door is secured on top by the door-latching mechanism, which actuates a slide-type latch that engages a stop on the doorjamb when the door handles are in the closed position. The Type III emergency exit doors are no longer used as emergency exits, but remain operable for maintenance access.

13. Cargo Doors (See Figure 1-18)

A. Four cargo doors, located on the right side of the fuselage, provide access to the forward and aft lower cargo compartments. Two types of doors, upward opening and downward opening (cross slide) are used in the DC-8 sixty series airplanes. The difference between the DC-8-62 series and the DC-8-61 and 63 series airplanes is the number of the two types used.


PASSENGER FORWARD ENTRANCE DOOR
FORWARD SERVICE DOOR
FORWARD UPPER CARGO DOOR
TYPE 1 EMERGENCY EXIT DOORS
OVERWING EMERGENCY EXIT DOORS
AIR-CONDITIONING COMPARTMENT DOOR
FORWARD LOWER CARGO COMPARTMENT FORWARD DOOR
FORWARD LOWER CARGO COMPARTMENT AFT DOOR
ACCESSORY COMPARTMENT DOOR
RIGHT CENTER SERVICE DOOR
LEFT CENTER SERVICE DOOR
AFT SERVICE DOOR
AFT LOWER CARGO COMPARTMENT FORWARD DOOR
AFT LOWER CARGO COMPARTMENT AFT DOOR
PASSENGER AFT ENTRANCE DOOR

FTX80658

FUSELAGE DOORS

Figure 1-18

B. On DC-8-62 series airplanes, one downward opening (cross slide) door is installed in the aft section of the forward cargo compartment and three upward opening doors are installed, one in the forward section of the forward cargo compartment, and one in the forward section and one in the aft section of the aft cargo compartment.

C. On DC-8-61 and 63 series airplanes, two downward (cross slide) opening doors are installed, one in the forward section of the forward cargo compartment and one in the forward section of the aft cargo compartment. and two upward opening doors are installed, one in the aft section of the forward cargo compartment and one in the aft section of the aft cargo compartment.

Some DC-8-61 series aircraft have cargo basket doors in place of the forward and aft cross slide doors. The forward doors for the cargo basket loading system are located on the lower centerline of the fuselage, the doors open inward and slide forward on tracks attached to the fuselage structure.

D. The downward opening (cross slide) doors open inward and downward along tracks attached to the fuselage frames so that when the door is in the full open position it will be positioned under a shroud, which forms part of the cargo compartment floor. the weight of the door is counterbalanced for opening and closing, by a control mechanism. The mechanism will hold the door in the full open position, and in the full up position so that the door may be latched closed by a latching mechanism actuated by an external handle. The upward opening doors open inward and upward along tracks attached to a support installed above the door opening. The doors are secured in the closed position by a latching mechanism actuated by an external handle and in the open position by hold-open hooks which must be manually released to close the door.

E. Douglas Door

In addition to the four cargo doors provided for access to the forward and aft lower cargo compartment, an upper cargo door is provided for the cabin and cargo compartment for the loading and unloading of cargo. The door is approximately 85 x 140 inches in size and is hinged at the top and opens outward and upward. The door is hydraulically operated by pressure supplied by the auxiliary hydraulic pump. A hand pump is provided to supply the pressure is pressure is not available from the auxiliary hydraulic pump.

F. RAI Door

The RAI cargo door is approximately 85 x 142 inches in size and is hinged at the top and opens outward and upward. The latches and locking assemblies operates electrically and hydraulically, the hydraulic system is separate from the aircraft, hydraulic system and the door operates by a system of valves, needle valves check valves, microswitches, relays, and circuit breakers. A handpump is provided to supply pressure if the hydraulic system fails.

CAUTION: IF DOOR IS OPENED MANUALLY, IT MUST BE CLOSED MANUALLY.

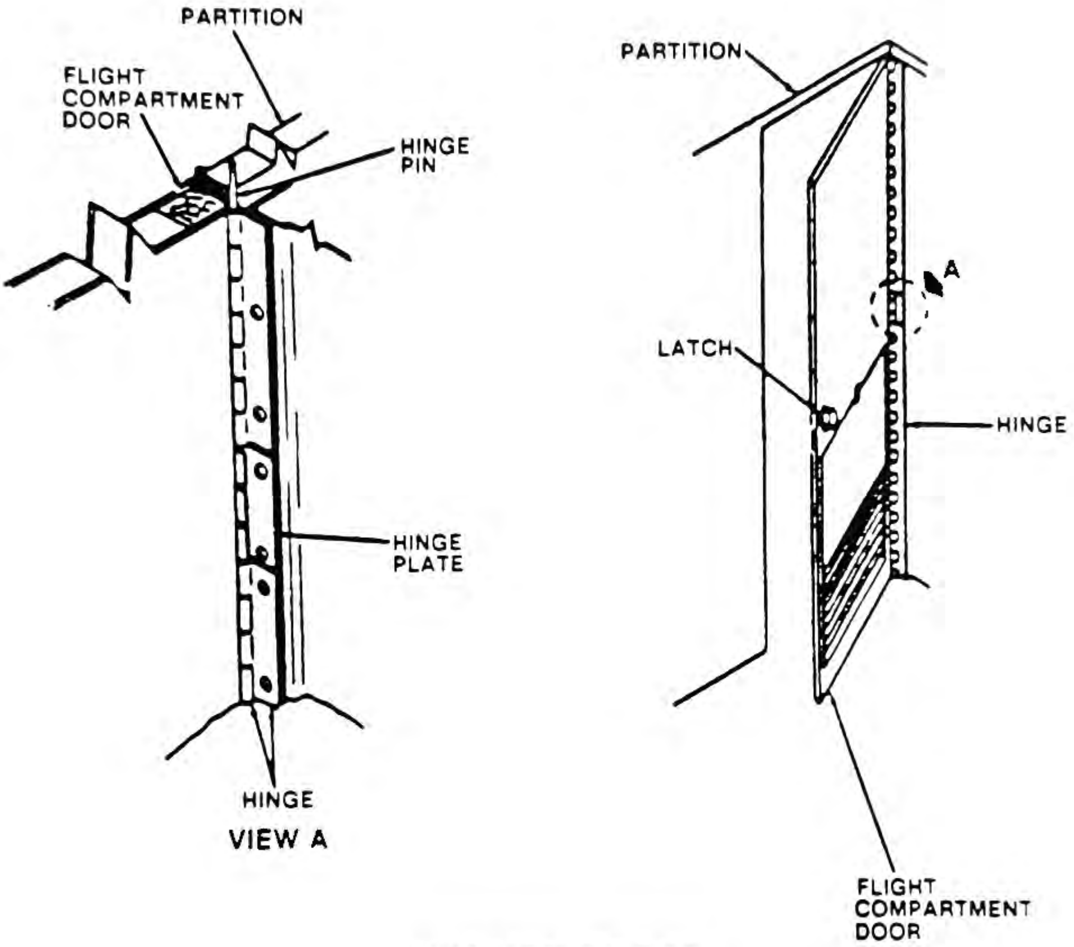
14. Service Doors (See Figure 1-18)

A. Service doors are provided for the cabin compartment, and the air-conditioning and accessory compartment. The service doors are located at the forward and aft section of the cabin compartment. The doors for the air-conditioning and accessory compartments are located on the lower centerline of the fuselage. The doors open upward and slide sideways on tracks attached to the fuselage structure. A hold-open hook holds each door in the open position. The hook is released by pulling on the door.

B. The service doors are similar in construction and identical in operation to the cabin doors, can be opened from either inside or outside the airplane by handles attached to a common shaft of the door mechanism. A window, located in the upper section of the door, permits viewing of the area adjacent to the door. A snubber, installed in the doorjamb of each door, protects against either wind gusts or personnel slamming the doors against the fuselage or the doorjamb. The number of service doors is dependent upon the configuration of the aircraft, the service doors have been deactivated by a series of bolts and nutplates, with the exception of the right-side aft service door which remains operable.

15. Fixed Interior Door (See Figure 1-19)

Doors are provided for the flight compartment. The lower section of the flight compartment door contains a louvered blowout panel. The panel is designed to blow forward if the pressure differential between the flight compartment and the cabin compartment is excessive. The door can be opened from either side



INTERIOR DOORS

FTX80659

Figure 1-19

by knobs that are attached to the shaft of the lock. The door can be locked from inside the flight compartment with a thumb latch and can be locked from the other side with a key.

16. Door Warning System

A. The door warning system provides the flight crew with visual indication when any of the pressure compartment external doors are opened.

B. The door warning system has limit switches that are installed in the doorjambs of the cabin and service doors, lower cargo doors, air-conditioning door, and accessory door (if equipped). The limit switches control a red press-to-test indicating light installed on the engineer's panel, and is divided into two parts. One light is placarded CABIN DOOR OPEN and the other light, BELLY DOOR OPEN. In addition to the CABIN and BELLY DOOR OPEN warning lights, there are annunciator lights on the FE panel. When the limit switch for an individual door is actuated, a specific annunciator light will illuminate.

C. The door warning system is provided into three circuits. one circuit contains the limit switches for the cabin and service doors, and operates the CABIN DOOR OPEN light. The second circuit contains the limit switches for the lower cargo compartments, the air-conditioning, and the accessory compartment doors (if equipped) and operates the BELLY DOOR OPEN light. The third circuit contains the annunciator light panel, each light in the panel is identified individually by door position and will illuminate when the specific door is opened.

(1) Douglas Door

The upper cargo door warning system has three limit switches and one proximity switch. The limit switches are installed in the doorjamb, the No. 6 latch position, and the vent door. The proximity switch is installed on the lockpin at Latch No. 2. The warning system is divided into two circuits. One circuit contains the limit switches which are included in the cabin and service door warning system and operates the CABIN DOOR OPEN, and the MAIN CARGO DOOR SYSTEM A warning lights. The other circuit contains the proximity switch which operates the MAIN CARGO DOOR SYSTEM B warning light on the engineer's panel.

(2) RAI Door

The upper cargo door has an independent warning circuit. The circuit contains a microswitch, that operates a warning light on the 9G bulkhead, and a warning light on the engineer's panel.

17. Forward Upper Cargo Door (Douglas)

A. General

The forward upper cargo door provides an opening in the fuselage for the loading and unloading of cargo when all or part of the passenger compartment is being used for cargo.

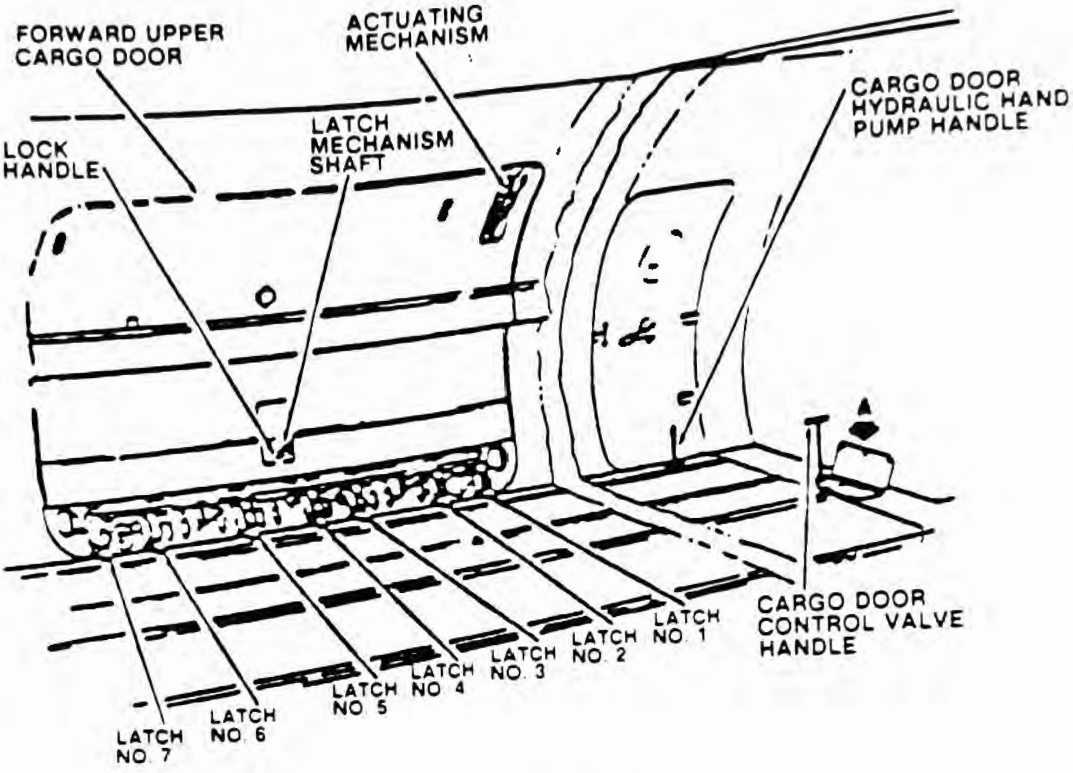
B. Description (See Figures 1-20, 1-21, 1-22 and 1-23)

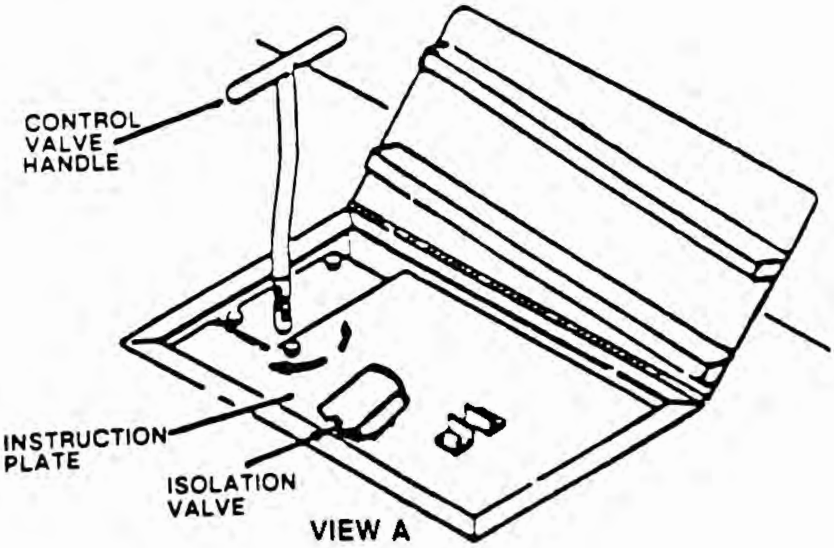
(1) The forward upper cargo door is located on the left side of the fuselage in the forward section of the cabin. The door is approximately 85 x 140 inches in size. The door is hinged at the top and opens outward and upward. The door is hydraulically operated by pressure supplied by the auxiliary hydraulic pump. A hand pump is provided to supply the pressure if pressure is not available from the auxiliary hydraulic pump.

(2) The structure of the door consists mainly of frames, intercostals, and stiffeners covered by inner and outer skins. A vent door installed at the AFT lower corner of the door prevents aircraft pressurization when the cargo door is not properly locked. A pressure seal is installed along the edge of the door to seal the door when the compartment is pressurized. A rain seal is installed along the upper edge of the door to protect the door lining when the door is open.

(3) The operating mechanism consists of a vent door installed at the AFT latch position, latch assemblies installed on the lower edge of the door which engage spools installed on the doorjamb, a torque tube, a latching cylinder, a walking beam, lock pins, lockpin cylinder, a mechanically actuated check valve, a door actuating cylinder, a hand pump, interconnecting rods, links, cranks, and a control valve.

C. Limit switches are installed on the vent door, NO. 6 latch lockpin, and the doorjamb. A proximity switch is installed on the No. 2 latch lockpin. These switches actuate the MAIN CARGO DOOR SYSTEM A and MAIN CAR-

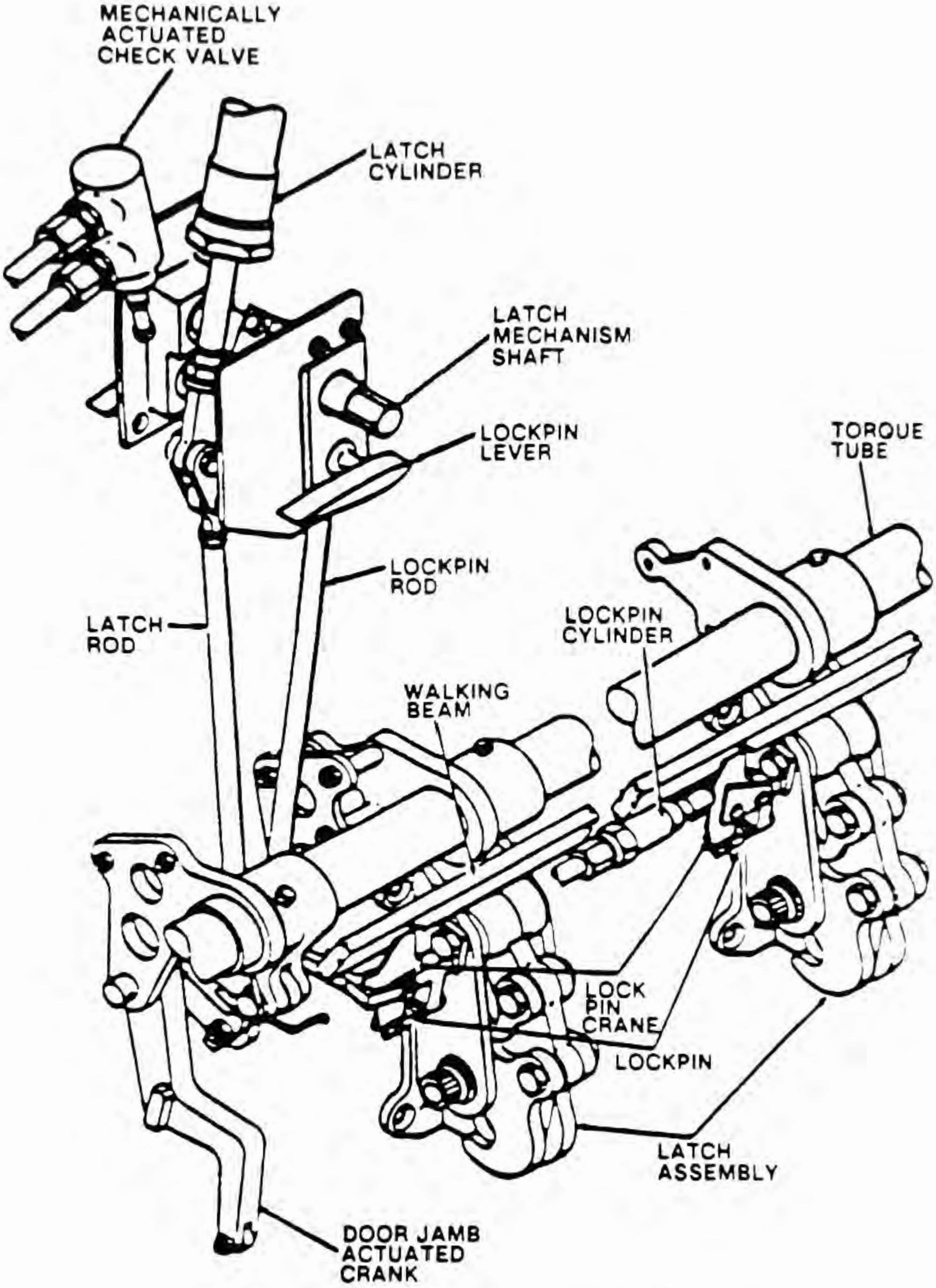




FORWARD UPPER CARGO DOOR

FTX80660

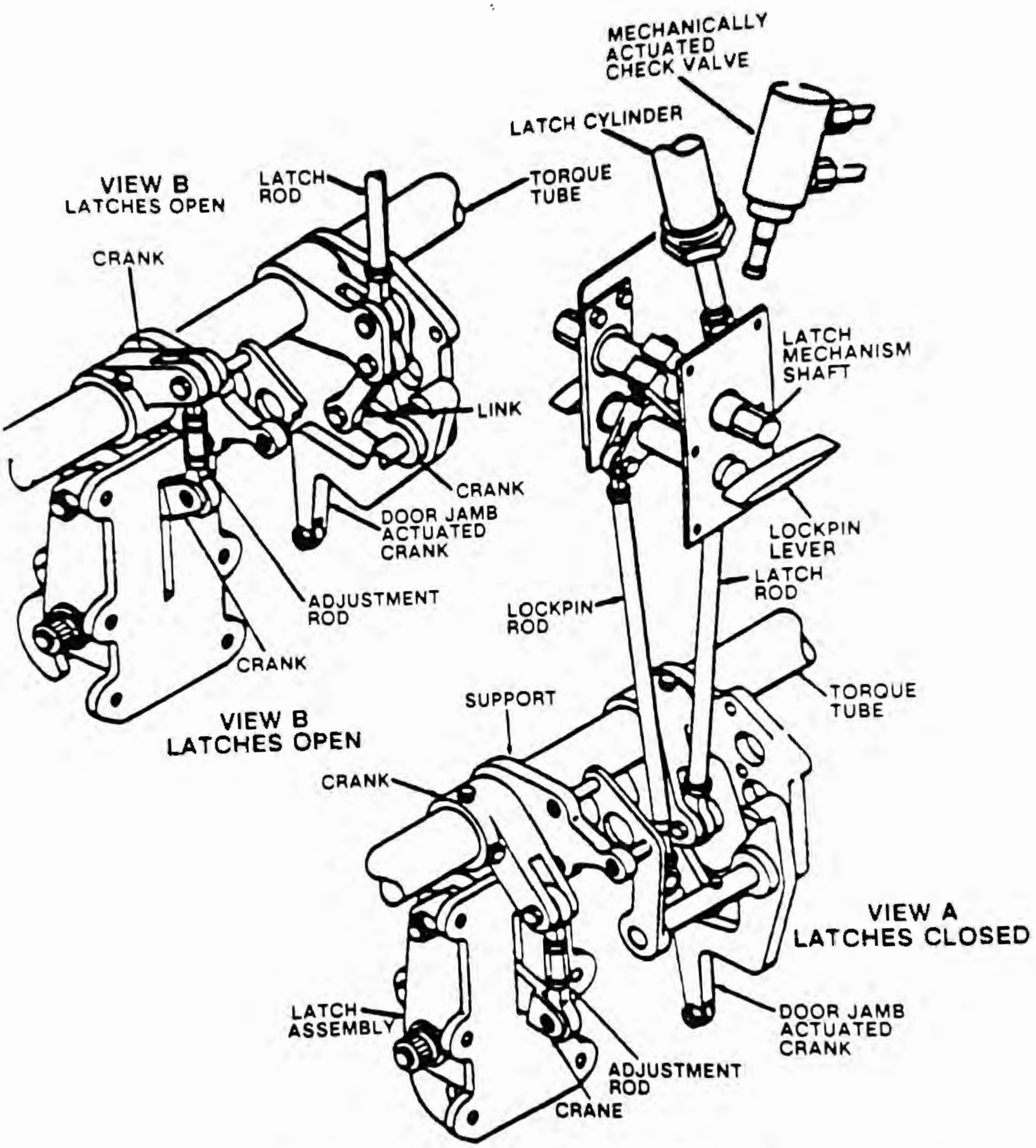
Figure 1-20



FORWARD UPPER CARGO DOOR

FTX80661

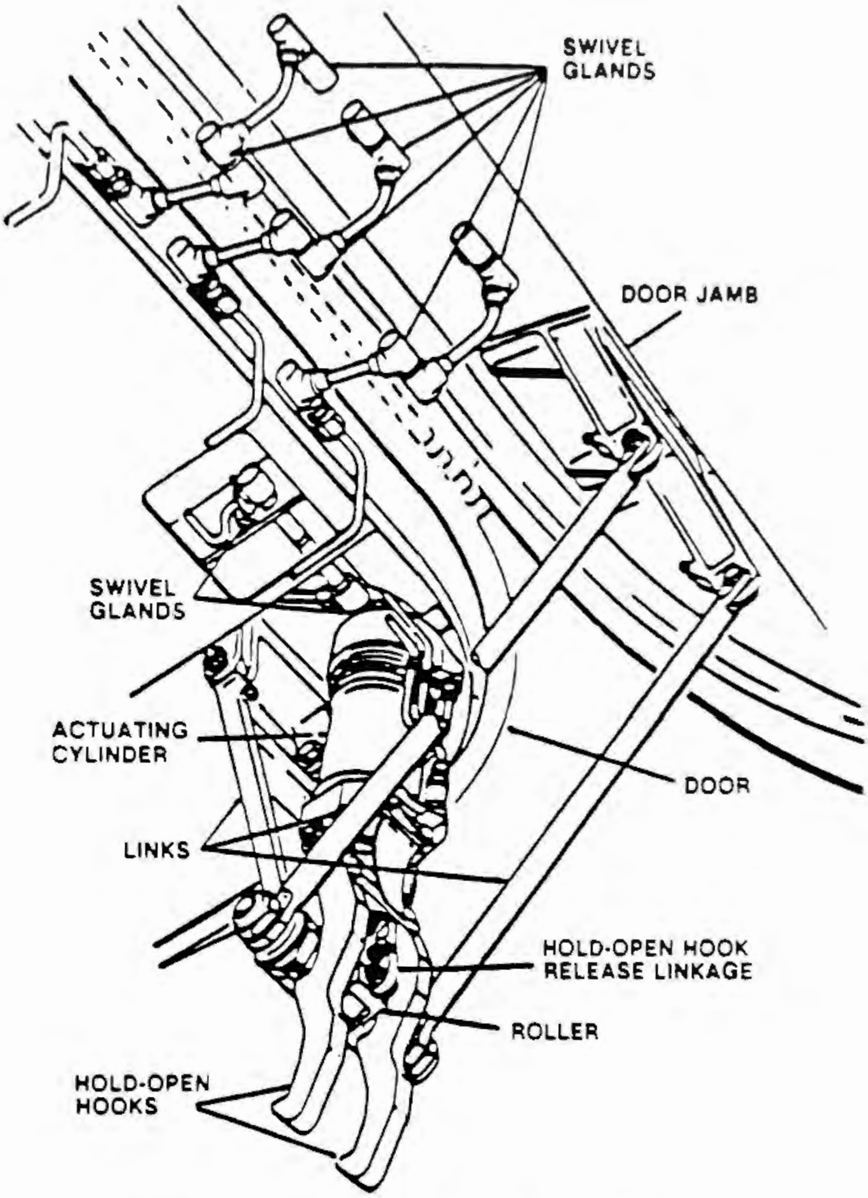
Figure 1-21



FORWARD UPPER CARGO DOOR

FTX80662

Figure 1-22



FORWARD UPPER CARGO DOOR

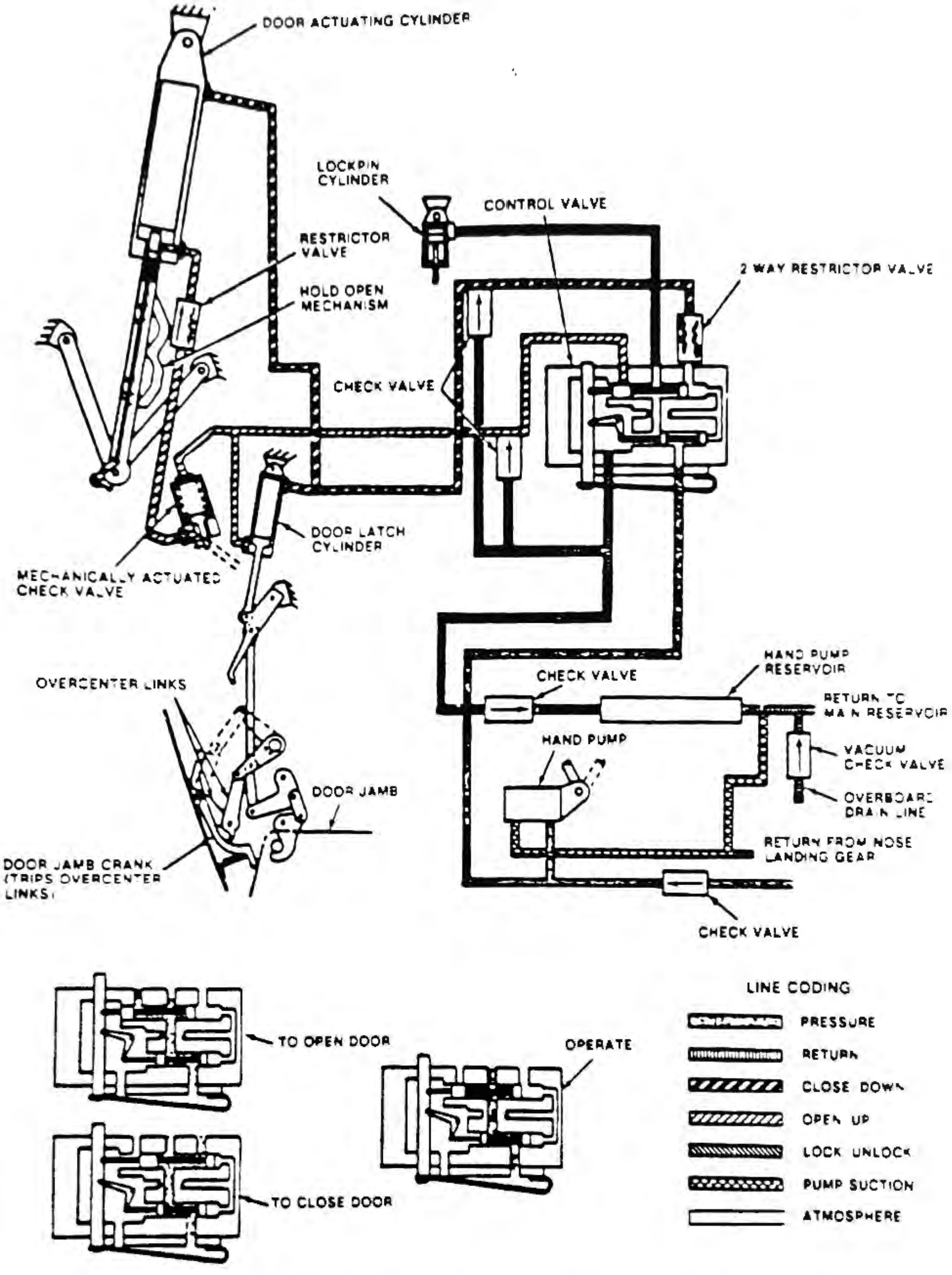
FTX80663

Figure 1-23

GO DOOR SYSTEM B warning lights in the flight compartment. The warning lights provide the flight crew with a visual indication of when the vent door and cargo door are unlatched and/or open.

D. The vent door prevents aircraft pressurization when the cargo door is not properly closed and latched. The latch assemblies latch the door firmly to the airplane structure when the door is closed. The latch assemblies are connected to the torque tube (which extends approximately the full length of the door just above the latches) by short rods. The torque tube is actuated, to open and close the latches, by the latch cylinder. The latches may be opened or closed manually by attaching a handle (the hand pump handle may be used) to a shaft on the torque tube actuating mechanism (the shaft extends through the door so that the latches may be actuated manually from inside or outside the airplane). The walking beam, which controls the movement of the lockpins by cranks and rods, is actuated by the lockpin cylinder to the unlocked position. The walking beam is spring loaded to return the beam and the lockpins to the locked position when hydraulic pressure is not applied to the lockpin cylinder. The walking beam may be actuated manually from inside or outside the airplane by a control lever attached to the walking beam actuating linkage. The lockpins lock the latch assemblies in the door latched position when the door is closed, and in the open position when the door is open to prevent closing of the latches with the door in the open position (the latches are also in an overcenter condition when the door is open). The door opening and closing mechanism consists of a cylinder and actuating links. One end of the cylinder is attached to the door structure. The other end is attached by the links to the door and the doorjamb. Hydraulic pressure to actuate the cylinder is controlled by the mechanically operated check valve. The valve is actuated by the latch assemblies torque tube mechanism when the latches are in the open position.

E. Operation of the door is controlled by the control valve. (See Figure 1-24) The valve is located in a well in the passenger compartment floor inboard of the passenger entrance door. The valve is controlled by a handle attached to the valve shaft. The valve has five positions, lock (control handle raised to the vertical position; or stowed in the clip on the valve operation instruction plate, and the valve shaft in the spring loaded down position), operate (control handle raised to the vertical position and pulled up to raise the valve shaft up and out of the spring loaded down lock position), open (control handle rotated to the right), close (control handle rotated to the left), and neutral (control handle in the operate position and the spring loaded position midway between the open and close positions).



FORWARD UPPER CARGO DOOR HYRAULIC SYSTEM

FTX 80664

Figure 1-24

The valve shaft is spring loaded to return to the neutral and lock positions.

NOTE: A solenoid operated isolation valve is installed in the forward upper cargo door hydraulic system to prevent inadvertent opening of the door during flight.

The isolation valve is controlled by a guarded ON-OFF switch located on the instruction plate adjacent to the control valve handle. The switch is placarded "CARGO DOOR ISOLATION VALVE SWITCH".

When closed (switch selected OFF), the valve prevents hydraulic power being supplied to the control valve from all sources except the hand pump. The hand pump can still be utilized to open and close the door when no electrical power is available.

With the isolation valve open (switch selected ON), the door can be operated using hydraulic power from the auxiliary pump, main system, or ground power source.

The valve is located at STA. 340 in the forward cargo compartment left side on the sidewall liner support structure.

The circuit breaker for the isolation valve is located at grid ref. C42, Cabin Bus No. 4, placarded "CARGO DOOR HYD SHUTOFF CONTROL".

(1) Door Operation

(a) Open vent door

MAIN CARGO DOOR SYSTEM A warning light in the flight compartment comes "ON".

(b) Ensure circuit breaker (C42) is closed.

(c) To open cargo door, lift guard and place cargo door isolation valve switch in ON position. Operate control valve handle per instruction plate to open door to desired position.

MAIN CARGO DOOR SYSTEM B warning light in the flight compartment comes "ON".

(d) To close cargo door, lift guard and place cargo door isolation valve switch in ON position. Operate control valve handle per instruction plate to close and lock door. When door is closed and locked select switch to OFF position (guard down).

MAIN CARGO DOOR SYSTEM B warning light in the flight compartment should be "OFF".

NOTE: If the switch is inadvertently left in the ON position, a sticker on the control valve access door automatically moves the switch to OFF when the access door is closed.

(e) Close vent door.

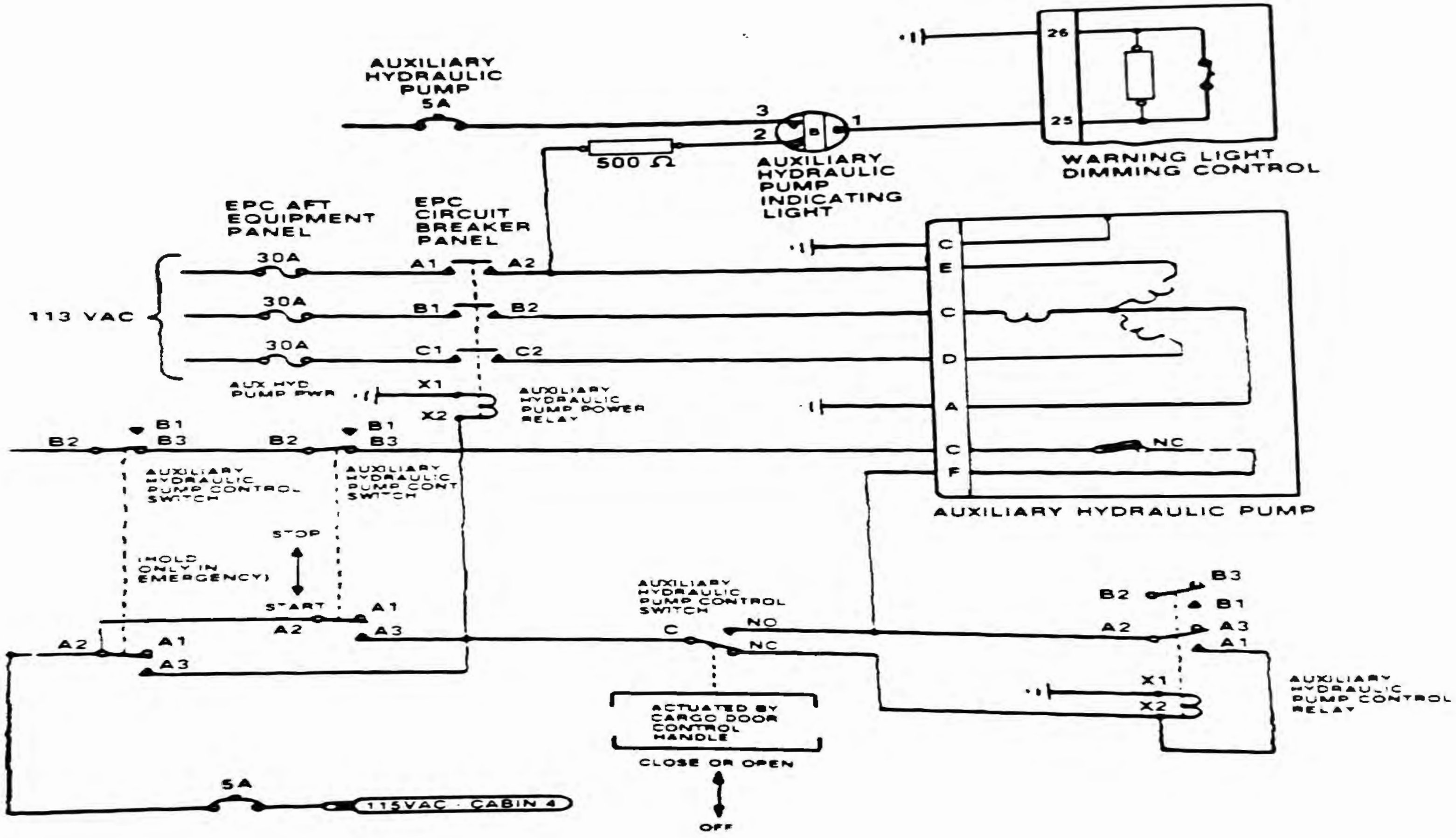
MAIN CARGO DOOR SYSTEM A warning light in the flight compartment goes "OFF".

(2) Check Isolation Valve Operation

(a) Select isolation valve switch to ON position and door should open or close per instruction plate.

(b) Select isolation valve switch to OFF position and door should not function.

F. The hydraulic system of the door receives hydraulic pressure whenever pressure is supplied to the nose gear down line by the main or auxiliary hydraulic pumps, or by external source. Normally hydraulic pressure is supplied by the auxiliary hydraulic pump (see Figure 1-25). The pump is controlled for cargo door operation, by a switch actuated by the shaft of the control valve. The hand pump is used to supply hydraulic pressure whenever normal hydraulic pressure is not available.


AUXILIARY HYDRAULIC PUMP 5A
3
2
B
1
500 Ω
AUXILIARY HYDRAULIC PUMP INDICATING LIGHT
26
25
WARNING LIGHT DIMMING CONTROL
EPC AFT EQUIPMENT PANEL
EPC CIRCUIT BREAKER PANEL
113 VAC
30A
30A
30A
A1
A2
B1
B2
C1
C2
AUX HYD PUMP PWR
X1
X2
AUXILIARY HYDRAULIC PUMP POWER RELAY
C
E
C
D
A
C
F
NC
AUXILIARY HYDRAULIC PUMP
B2
B1
B3
B2
B1
B3
AUXILIARY HYDRAULIC PUMP CONTROL SWITCH
AUXILIARY HYDRAULIC PUMP CONT SWITCH
STOP
(HOLD ONLY IN EMERGENCY)
START
A1
A2
A3
A2
A1
A3
AUXILIARY HYDRAULIC PUMP CONTROL SWITCH
C
NO
NC
ACTUATED BY CARGO DOOR CONTROL HANDLE
CLOSE OR OPEN
OFF
B3
B2
B1
A2
A3
A1
X1
X2
AUXILIARY HYDRAULIC PUMP CONTROL RELAY
5A
115VAC · CABIN 4

AUXILIARY HYDRAULIC PUMP CONTROL - SCHEMATIC

FTX80665

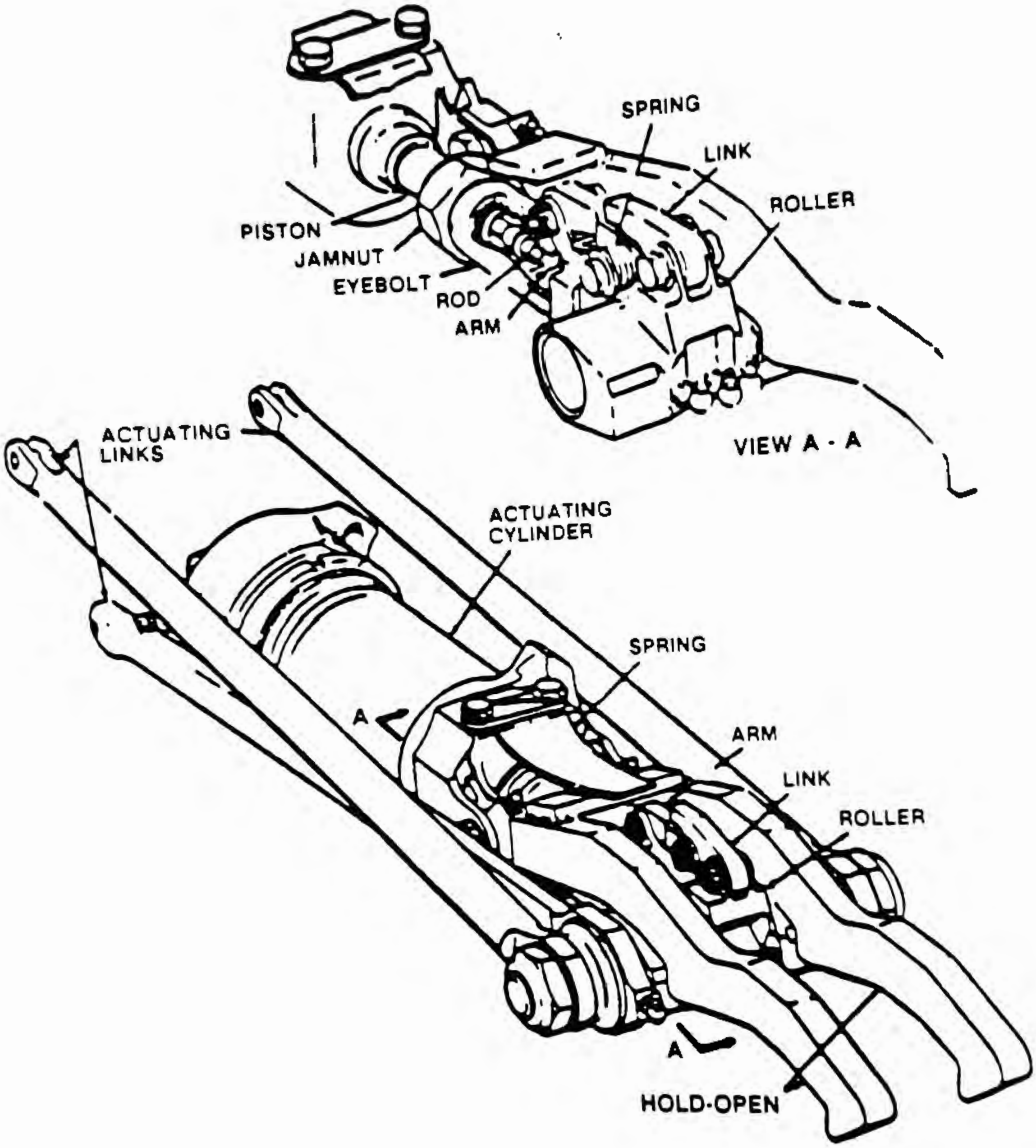
Figure 1-25

18. Component Description

A. Forward Upper Cargo Door Actuating Cylinder (See Figures 1-26 and 1-27)

(1) The function of the upper cargo door actuating cylinder is to open and close the cargo door. The cylinder consists of a barrel, actuating piston, a spring-loaded hook mechanism release rod, a barrel head, eyebolt fitting, a spring-loaded hold-open hook, a hook mechanism, and the necessary o-rings to prevent external and internal leakage of the cylinder. Two external ports, one in the barrel and one in the barrel head provide for connecting pressure/return lines to the cylinder. The barrel head is of the clevis type and anchors the cylinder to the door structure. The eyebolt fitting is installed on the end of the actuating piston and supports the hook mechanism. The fitting is connected to actuating links which are attached to the door and doorjamb. The hook mechanism release rod is contained within the actuating piston and unlocks the hook mechanism by forcing a spring-loaded arm and link of the hook mechanism from an overcenter position.

(2) When pressure is applied to the retract port of the cylinder, the actuating piston retracts and the door opens. The shape of the spring loaded hold-open hooks allow the hooks to guide over the hook mechanism roller when the door is opening. The hold-open hooks are detented to hold the door open at the 86- and 166-degree positions without hydraulic pressure. When pressure is applied to the extend port of the cylinder, the actuating piston and hook mechanism release rod is extended. When the release rod is extended the spring loaded arm and link of the hook mechanism is forced from the overcenter position to allow the hold-open hooks to rotate the hold-open hook mechanism roller to a position to release the hooks. The hold-open release rod will remain extended as long as pressure is applied to the extend port of the cylinder. When pressure to the extend port of the cylinder is relieved the spring of the hook release rod will return the rod to the retracted position and the arm and link of the hook mechanism will return to their overcenter position.

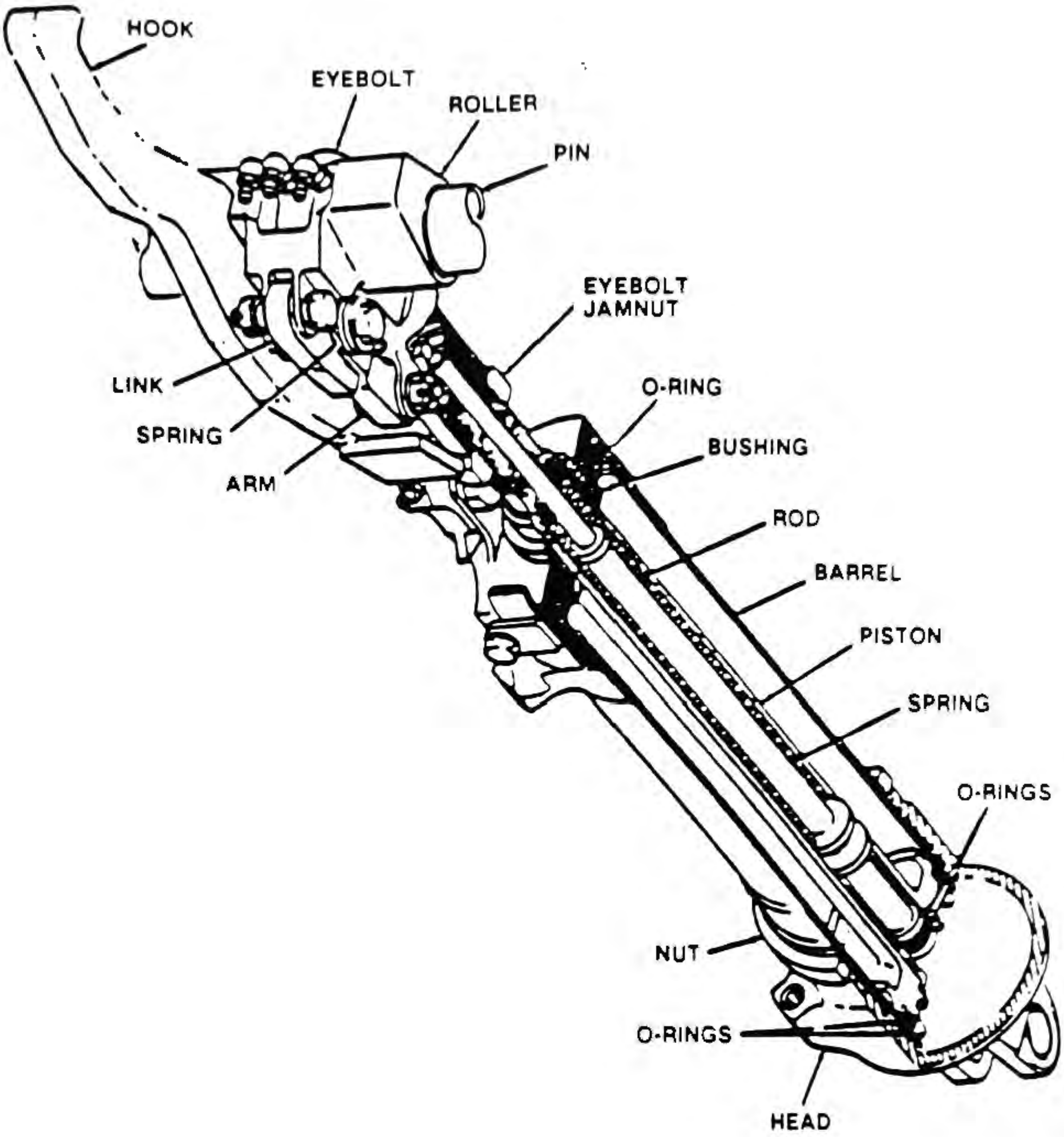


FORWARD UPPER CARGO DOOR ACTUATING CYLINDER
FIGURE 4 (SHEET 1 OF 2)

FTX80666

Figure 1-26

]



FORWARD UPPER CARGO DOOR ACTUATING CYLINDER
FIGURE 4 (SHEET 2 OF 2)

FTX80667

Figure 1-27

B. Forward Upper Cargo Door Control Valve (See Figure 1-28)

(1) The function of the forward upper cargo door control valve is to control the operation of the door. The control valve consists of two slide type valves in a single body. One valve has two positions, lock and operate, and the other three positions, neutral, open, and close. The slides of the valve are connected to a single shaft. The shaft is spring loaded to return the slides to the lock and neutral positions.

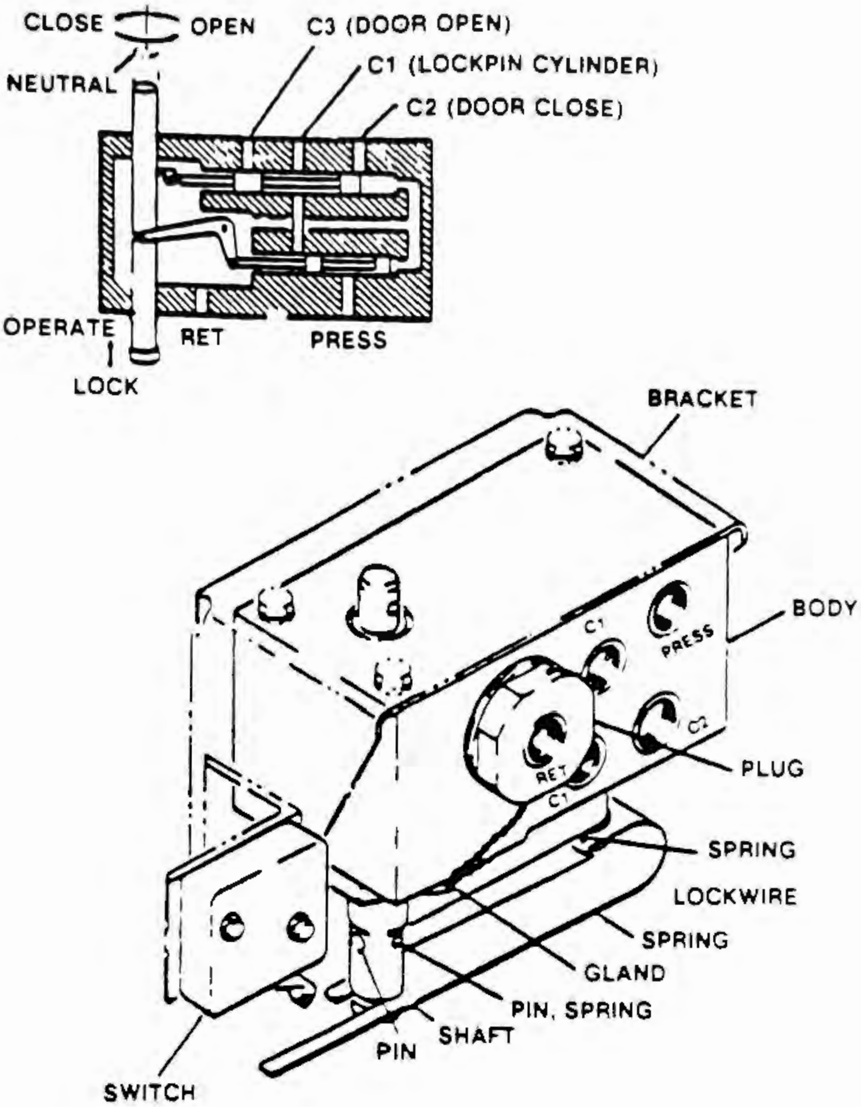
(2) The valve is installed in a well in the floor of the passenger compartment inboard of the passenger forward entrance door. The well is covered by a door which is secured to the floor by quick release fasteners. A handle is attached to the shaft of the valve to control the valve operation. When not in use the handle may be folded downward into the well and secured by a clip. A switch is attached to the valve body for controlling the auxiliary hydraulic pump for cargo door operation. The switch is actuated by the valve shaft spring.

C. Forward Upper Cargo Door Latch Cylinder (See Figure 1-29)

The function of the forward upper cargo door latch cylinder is to open and close the cargo door latch assemblies. The cylinder consists of a barrel head, piston, barrel end nut, adjustable rod end, and the necessary o-rings to prevent external and internal leakage. Two external ports, one in the barrel and one in the barrel end provide for connecting pressure/return lines to the cylinder. The barrel head is of the clevis type and is used to attach the cylinder to the door structure. The barrel end nut attaches to the barrel opposite the barrel head. The nut has a hole in the center to allow the actuating piston to extend and retract. The adjustable rod end is installed on the actuating piston and connects the piston to the mechanism of the latch assemblies.

D. Forward Upper Cargo Door Lockpin Cylinder (See Figure 1-29)

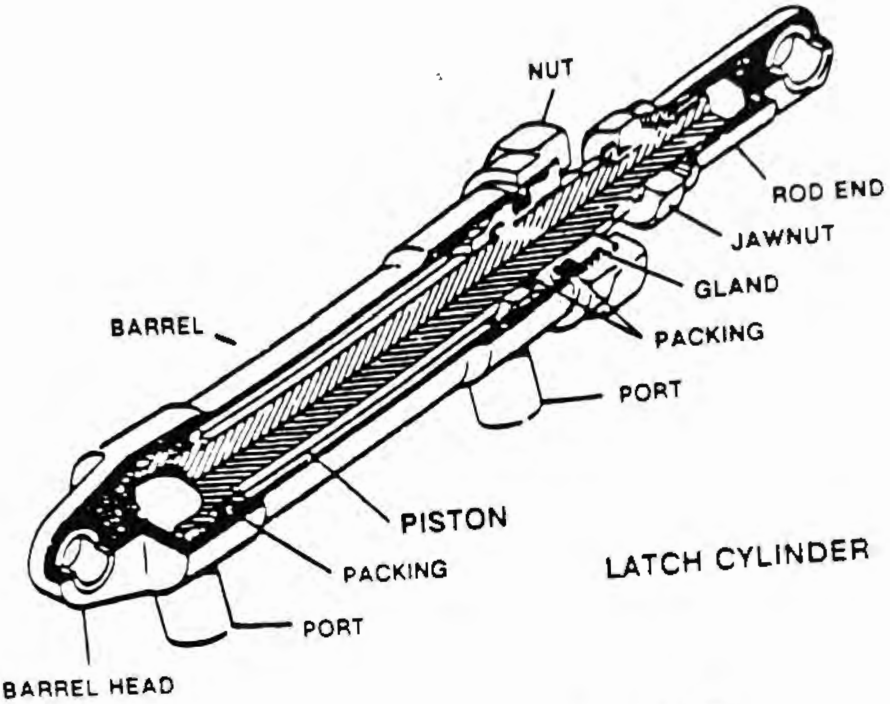
The function of the forward upper cargo door lockpin cylinder is to move the lockpin walking beam to disengage the lockpins from the cargo door latch assemblies. The cylinder consists of a barrel, a piston, and the necessary o-rings to prevent external and internal leakage of the cylinder. A fitting is installed on one end of the barrel to connect a pressure/return line. External threads on the piston rod end of the barrel are provided for attaching the cylinder to a threaded support on the door structure.



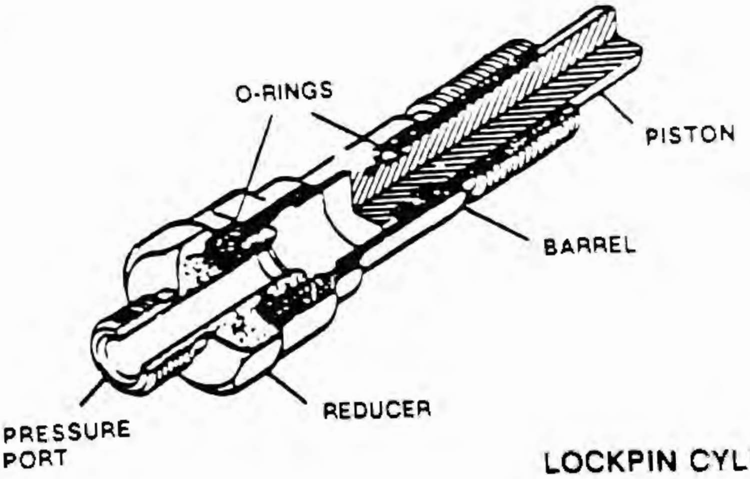
FORWARD UPPER CARGO DOOR ACONTROL VALVE

FTX80668

Figure 1-28



LATCH CYLINDER



LOCKPIN CYLINDER

FORWARD UPPER CARGO DOOR LATCH AND LOCKPIN CYLINDERS

FTX80669

Figure 1-29

E. Forward Upper Cargo Door Hydraulic Hand Pump (See Figure 1-30)

The forward upper cargo door hydraulic hand pump is a single-piston double-action type hand pump. The pump is used to supply hydraulic pressure to the cargo door hydraulic system when the auxiliary hydraulic pump is not used. The pump consists of a pump body with suction and pressure ports, check valves, piston, a link and the necessary o-rings to prevent external and internal leakage. When the piston of the pump is extended fluid is forced out on the extend side of the piston and sucked in from the reservoir on the retract side. When the piston of the pump is retracted the process is reversed. The pump is remotely operated by a rod attached to the link, which is connected to the piston, and a handle fitting installed in the floor of the passenger compartment adjacent to the passenger forward entrance door. The pump is installed on the floor structure just below the floor, and adjacent to the lower forward corner of the cargo door.

F. Forward Upper Cargo Door Lining

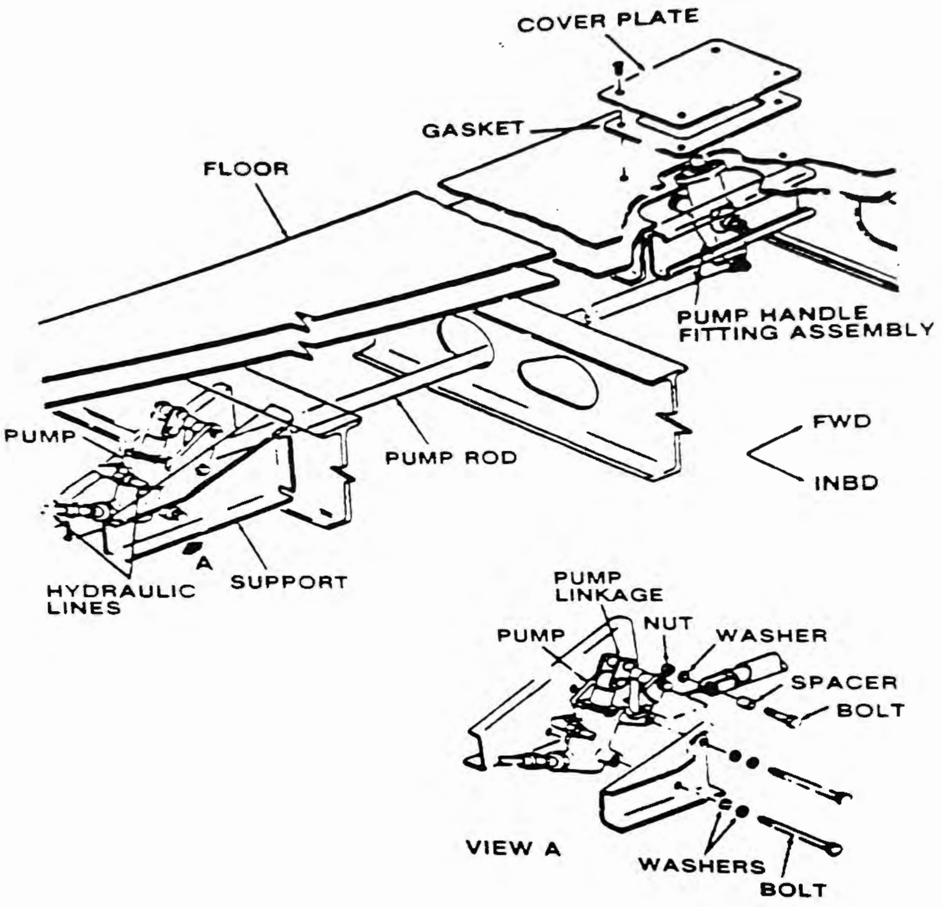
The forward upper cargo door lining serves as a vibration, heat and sound insulator, a decorative cover for the door structure, and a protection for the door operating mechanisms. The lining consists of panels similar in construction to the passenger compartment side panels. Provisions are made in the lining for the installation and attachment of equipment required when passenger seats are installed in the cargo door area.

G. Forward Upper Cargo Door Pressure Seal

The forward upper cargo door pressure seal is installed along the edge of the door. The seal consists of molded rubber tubular sections vulcanized together. The seal is secured to the door by retainer strips inserted in the seal and attached to the door structure by screws.

H. Forward Upper Cargo Door Vent Door (See Figure 1-31)

The main cargo door is fitted with a vent door, warning switch, and integral structural blocking around the upper cargo door torque tube. The vent door cannot be closed and latched unless the blocking is in the proper position, indicating a properly latched and locked upper cargo door. The purpose of the vent door is to prevent aircraft pressurization when the main cargo door is not properly latched. The purpose of the warning switch



FORWARD UPPER CARGO DOOR HYDRAULIC HAND PUMP

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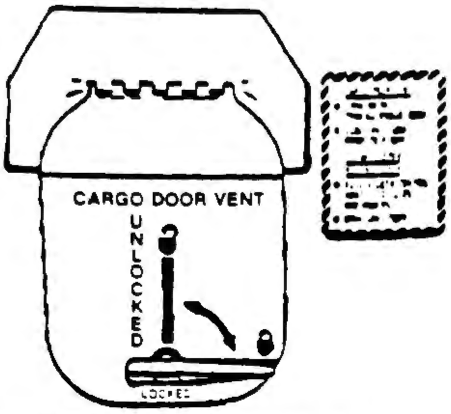
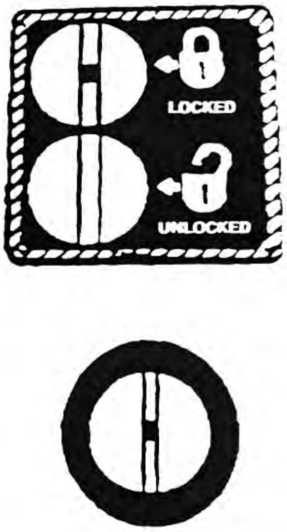
Figure 1-30



FORWARD UPPER CARGO DOOR VENT



EXTERNAL VIEWING WINDOW

CARGO DOOR VENT AND EXTERIOR VIEW PORT

FTX80671

Figure 1-31

is to indicate the position of the vent door, and alert the flight crew of an open and unlocked vent door.

19. Operation

CAUTION: TO PREVENT POSSIBLE STRUCTURAL DAMAGE TO AIRPLANE, FORWARD UPPER CARGO DOOR MUST BE CLOSED AND LATCHED WHEN RAISING (JACKING) OR LOWERING AIRPLANE. NO CARGO IS TO BE LOADED OR UNLOADED FROM PASSENGER/CARGO COMPARTMENT WHILE AIRPLANE IS ON JACKS.

CAUTION: DO NOT TOW OR TAXI AIRPLANE WITH FORWARD UPPER CARGO DOOR OPEN OR UNLATCHED. DO NOT OPEN CARGO DOOR IF ACTUAL OR ANTICIPATED WIND VELOCITY WILL EXCEED 40 KNOTS, EXCEPT UNDER FOLLOWING CONDITIONS:

> CARGO DOOR MAY BE OPENED TO 86 DEGREE OR 166 DEGREE POSITIONS WITH MAXIMUM WIND VELOCITY OF 40 KNOTS (STEADY) OR GUSTS TO 52 KNOTS.
>
> IF WIND VELOCITIES FROM 40 TO 65 KNOTS ARE ANTICIPATED CARGO DOOR MAY BE OPENED TO 86 DEGREE POSITION ONLY IF AIRPLANE IS PARKED SO THAT WIND DIRECTION IS AGAINST RIGHT SIDE OF AIRPLANE.

WIND VELOCITIES GREATER THAN 40 KNOTS DIRECTED AGAINST LEFT SIDE OF AIRPLANE WILL BLOW CARGO DOOR FROM 86 DEGREE POSITION TO FULL OPEN OR BEYOND THEREBY CAUSING DAMAGE TO FUSELAGE/CARGO DOOR.

A. To operate the cargo door with the normal hydraulic system, CABIN BUS 4 must be energized. The following circuit breakers must be closed. The auxiliary hydraulic pump control, and the cargo hydraulic control, located on the EPC breaker panel.

WARNING: TO PREVENT POSSIBLE INJURY TO PERSONNEL OR DAMAGE TO AIRPLANE MAKE CERTAIN THAT ALL HYDRAULICALLY ACTUATED SYSTEMS ARE IN A SAFE CONDITION BEFORE ACTUATING CARGO DOOR HYDRAULIC CONTROL VALVE HANDLE.

B. Two additional safety features have been incorporated into the door locking mechanism.

(1) An exterior view port installed on the lower forward door section. allows visual inspection of the door latch indicator. When a SOLID line can be seen the latches are UNLOCKED. When a SEPARATED line can be seen the latches are LOCKED.

(2) A vent door installed at the AFT latch position, prevents aircraft pressurization when the main cargo door is not properly closed and latched.

C. To open the cargo door, the vent door must be opened. Place the cargo door hydraulic control valve handle in the operate position, then rotate the handle to the open position. Moving the control handle from the lock to the operate position, closes the contacts of the auxiliary hydraulic pump control switch. Connecting electrical power to the auxiliary hydraulic pump opens the pump pressure shutoff section of the control valve, pressure is then ported through internal ports in the valve, the door actuating section of the valve, and through external ports to the lockpin cylinder (linkage and cranks connected to the piston of the lockpin cylinder move the lockpin walking beam forward, pivoting the lockpin cranks and disengaging the lockpins from the latches). When the control handle is rotated to the open position, pressure is routed through an external port of the valve to the retract port of the latch cylinder. Linkage and cranks connected to the latch cylinder piston rotate the latch mechanism torque tube, rods connected to the torque tube and the latch assemblies actuate the latch mechanism to move the latch hooks to the open position. The check valve is actuated by the latch mechanism linkage and when the latches are open ports pressure to the retract port of the door actuating cylinder and opens the door. As the door opens, a crank actuated by the doorjamb, releases spring-loaded links on the latch mechanism, allowing the links of the latch assemblies to move to an overcenter position. This prevents the latching cylinder from closing the latches when the control handle is placed in the closed position and the door is not fully closed. When the spring-loaded control valve is released it will return to the neutral and lock positions, deenergizing the auxiliary hydraulic pump.

D. The door is held open at 86 and 166 degrees by a hydraulically controlled hold-open mechanism attached to the door actuating cylinder. The hook of the hold-open mechanism is detented to hold the door open at approximately 86 and 166 degrees without hydraulic pressure. When the opening motion of the door is stopped at either of these positions, a roller of the hook mechanism engages the detent on the hook and prevents the door from closing until the control handle is placed in the close position and hydraulic pressure is applied to the system. To position the door on the hold-open hook at the 86 or 166 degree position, the door must be opened to a position a few degrees higher than the desired position. The door control valve handle is then allowed to return to the spring-loaded neutral and lock position; then, with the control handle in the lock (valve shaft down) position, the control handle is rotated momentarily to the closed position until the door rests on the hook.

NOTE: If the door control valve handle is not in the lock position when the handle is rotated to the close position, pressure will be applied to the close side of the door actuating cylinder and the hold-open mechanism will be tripped from the overcenter position and the door will close.

NOTE: The door is an overcenter position when the piston rod of the door actuating cylinder is fully retracted. This condition prevents the door from resting on the hold-open hook at the 166 degree position when the control valve handle is rotated to the close position.

E. When the control handle is allowed to return to the neutral position, the pressure is trapped in the door actuating and latch cylinders to hold the door and latches open (the latches will remain open without hydraulic pressure). When the control handle is released and allowed to return to the lock position, the pressure in the lockpin cylinder is relieved. The spring-loaded walking beam will then move aft and the lockpins will engage a plate on the latch assemblies to lock the latch hooks in the open position.

F. To close the door, the control handle is placed in the operate position, then rotated to the open position to lift the door off the hold open hook (this reduces fatigue loads on the hold-open hook mechanism caused by the simultaneous release of the hold-open hook and the downward motion of the door). The control handle is then placed in the close position. When the control handle is in the close position, pressure is ported to the extend port of the door actuating cylinder, latch cylinder and to the lockpin cylinder. When pressure is applied to the extend port of the door actuating cylinder. the hold-open mechanism is released and the actuating cylinder piston is extended to close the door. When pressure is applied to the lockpin cylinder, the piston extends to move the lockpin walking beam forward to disengage the lockpins from the plates on the latches, which allows the latches to be closed. When the door closes, the doorjamb actuated crank trips the spring loaded latch mechanism links from overcenter to allow the latch cylinder piston to extend and close the latches. When the door is closed and latches, the door control handle is released and allowed to return to the neutral and lock positions. When the control valve is in the neutral and lock positions, the pressure in the lockpin cylinder is relieved. and the spring loaded walking beam will move aft to engage the lockpins with the latches to lock the latch assemblies in the door latched position. When the latch assemblies are closed and locked, and the black and white lines on the latches are in alignment. The vent door can then be closed and latched.

G. The door control section of the control valve is open to the hydraulic system return line when the control handle is in the neutral or lock positions. This relieves the pressure on the extend side of the door actuating cylinder and the latch cylinder pistons when the door is stationary. The pump pressure shutoff section of the control valve is open to the system return line when the valve is in the lock position. This relieves the pressure in the lockpin cylinder. The relieving of the pressure in the door closed section of the door hydraulic system reduces the possibility of leakage due to pressure being trapped in the system for an extended period of time when the door is closed. This also permits the latch assemblies to be actuated manually with the manual controls located on the door.

H. A restrictor at the retract port of the door actuating cylinder and a restrictor at the extend port of the control valve controls the door opening and closing speeds. Four check valves are installed in the lines of the door hydraulic system. One check valve is installed upstream from the control valve to stop backflow of fluid through the nose gear line. A second check valve is installed between the hand pump reservoir and the control valve to prevent the flow of fluid from the reservoir into the airplane main hydraulic system. A vacuum relief valve is installed in the reservoir overboard vent line to prevent the flow of fluid overboard when the reservoir is full.

The third check valve is installed in the door actuating cylinder down line between the control valve and the cylinder. When the system pressure is off this check valve allows fluid to flow from the upside to the downside of the actuating cylinder, this allows the hold-open to support the door. The fourth check valve is installed in the actuating cylinder up line between the control valve and the cylinder. When the system pressure is off, the check valve allows fluid to flow from the downside to the upside of the cylinder when air loads tend to lift the door when the door is open.

I. Operation of the door with the hand pump is the same as the pressure supplied by the auxiliary hydraulic pump, except that electrical power is not required. The check valve installed in the nose gear pressure line upstream from the control valve prevents the hand pump pressure from being applied to the nose gear down line.

J. A system relief valve set to open at 3300 psi (full flow at 3500 psi) and reset at 3000 psi is installed between the pressure line and the system return line to relieve both the auxiliary hydraulic pump pressure and the hand pump pressure.

K. To operate the door manually the lockpin control lever must be actuated (and held until the latches start to open) to the unlocked position, and the latch mechanism shaft rotated to the open position (the hand pump handle may be used as a handle for the latch mechanism shaft). When the latches are open the door will swing open far enough to clear the latch assemblies from the spools on the doorjamb. The door may be raised to the desired position by means of a sling and hoist. If the door is raised passed the 86 degree position, the hold-open mechanism must be released manually to close the door.

L. When the vent door is unlatched and opened, a limit switch on the vent door completes a ground circuit to the MAIN CARGO DOOR SYSTEM A warning light in the flight compartment. When the cargo door is unlatched and opened, limit switches actuated by the lockpin crank at No. 6 latch and the doorjamb complete a ground circuit to the MAIN CARGO DOOR SYSTEM A warning light. When the proximity switch at No. 2 latch lockpin is actuate a ground circuit to the MAIN CARGO DOOR SYSTEM B warning light is completed. These warning lights provide the flight crew with a visual indication that the vent door and cargo door are unlatched and/or open.

20. R.A.I. Forward Upper Cargo Door - Description and Operation

A. General

(1) The forward upper cargo door provides an opening in the fuselage for the loading and unloading of all cargo.

(2) The forward upper cargo door is located on the left side of the fuselage, with the forward edge of the door located at approximately STA 130. The door is approximately 85 x 142 inch in size. The door is hinged at the top and opens outward and upward. The door operates hydraulically and electrically by a system of control valves, needle and check valves, restrictors, hydraulic pump, reservoir, relief valve, switches, relays, microswitches.

B. Description - Hydraulic System (See Figure 1-32)

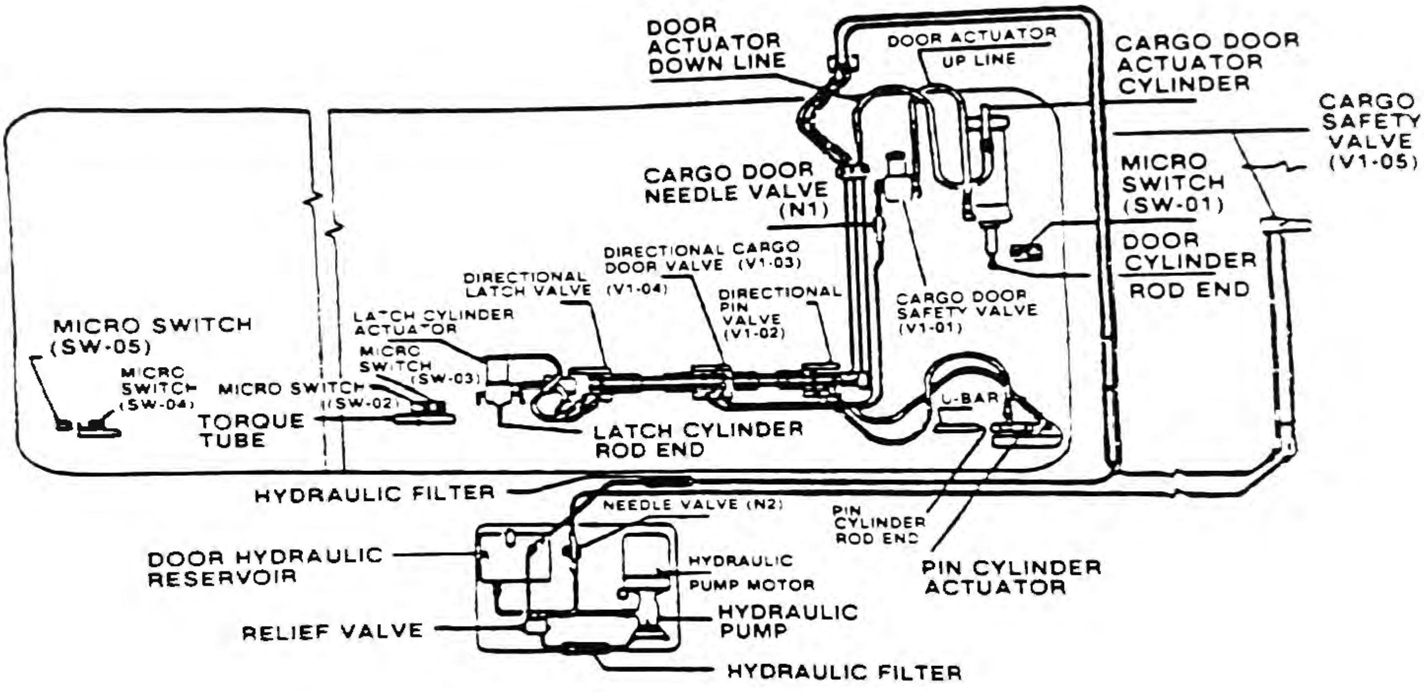
The hydraulic system for the cargo door is separate from the aircraft main hydraulic system. The doors hydraulic system uses MIL-L-5606 FLUID ONLY and has an operating pressure of approximately 2900 PSI. The hydraulic system consists of the following components.

(1) The reservoir receives its supply of hydraulic fluid from a tank located in the left side of the forward lower cargo compartment. The reservoir has a capacity of approximately 1.5 gals. A dip stick, attached to the reservoir cap, is marked for the correct amount of fluid, when the door is in a closed position, and there is no pressure on the system.

(2) The hydraulic pump is located in the left side of the forward lower cargo compartment. The motor is electrically driven from BUSS #4 by 115 VAC, 3-phase, 400 cycle power.

(3) The hydraulic filter is located in the left side of the forward lower cargo compartment. There are two filters, one located in the pressure line downstream of the hydraulic pump, the other filter is located in the return line at the reservoir.

(4) The relief valve is located in the left side of the forward lower cargo compartment. If the fluid pressure in the system becomes excessive (over 2900 PSI), the relief valve bleeds pressure off and returns the fluid to the reservoir.



R.A.I. CARGO DOOR - ELECTRICAL AND HYDRAULIC LAYOUT

FTX80672

Figure 1-32

(5) The needle valve (N2) is located in the left side of the forward lower cargo compartment. The needle valve is manually adjustable to the desired flow of hydraulic fluid to the door system.

(6) The safety valve (V1-05) is located in the left side of the 9G Bulkhead at STA 63. The safety valve functions as a check valve and is manually operated. The valve must operate to allow fluid to flow downstream.

(7) The directional pin valve (V1-02) is located on the lower cargo door at STA 161. The valve is a three position, closed center, electrically operated valve. The electrical power is 28 VDC from BUSS #1. When the valve is energized, it supplies hydraulic fluid to the pin cylinder.

(8) The pin cylinder is located on the lower forward corner of the cargo door and actuates the safety pins.

(9) The directional latch valve (V1-04) is located on the lower cargo door at STA 187. The valve is a three position, closed center, electrically operated valve. The electrical power is 28 VDC from BUSS #1. When the valve is energized, it supplies hydraulic fluid to the latch cylinder. (See Figure 1-32)

(10) The latch cylinder is located on the lower center of the cargo door and actuates the latches.

(11) The directional cargo door valve (V1-03) is located on the lower cargo door at STA 174. The valve is a three position, closed center, electrically operated valve. The electrical power is 28 VDC from BUSS #1. When the valve is energized, it supplies hydraulic fluid to the cargo door cylinder. (See Figure 1-32)

(12) The open and closing needle valve (N1) is located in the upper forward corner of the cargo door. The needle valve is manually adjustable to the desired flow of the opening and closing of the cargo door.

(13) The cargo door safety valve (V1-01) is located in the upper forward corner of the cargo door. The valve is a two way, normally closed, electrically operated valve that functions as a check valve. The electrical power for the valve is 28 VDC from BUSS #1. When the valve is energized, it opens its ports and allows fluid to pass. (See Figure 1-32)

(14) A restrictor is located at each port of the cargo door cylinder. The restrictor is a #6 hydraulic fitting with one end welded closed and a #60 hole drilled through it. The function of the restrictors is to further slow down the flow of hydraulic fluid to and from the cylinder.

(15) The cargo door cylinder is located on the upper forward corner of the cargo door and actuates the cargo door.

C. Description - Electrical System

(1) The electrical system consists of two types of power, 28 VDC and 115 VAC, 3-phase, 400 cycle. The 28 VDC power comes off of BUSS #1 and is used to operate the hydraulic valves and the cargo warning system. The 115 VAC comes off of BUSS #4 and is used to operate the relay and the hydraulic pump. (See Figure 1-33)

(a) The 28 VDC electrical power supplied form BUSS #1 for cargo door operation is protected with two (5) AMP single pole circuit breakers. One located on the EPC panel in the upper right corner and the other on the cargo door control panel on the left hand forward wall of the 9G bulkhead. The power is then directed to two switches located on the cargo door control panel. The two switches are double pole, double throw, but are tied together by a gang bar so they function as a four pole, double throw switch.

1 The first pole switch (SW-07) provides a ground to the relay to operate the hydraulic pump.

2 The second pole switch (SW-07) directs the power to the effective valve and applicable microswitch depending on the position of the door and the placement of the toggle lever.

3 The third pole switch (SW-06) directs the power to the cargo door safety valve located in the upper forward corner of the cargo door. The cargo door safety valve is energized in either position of the toggle switch lever.

4 The fourth pole of the switch is not used.

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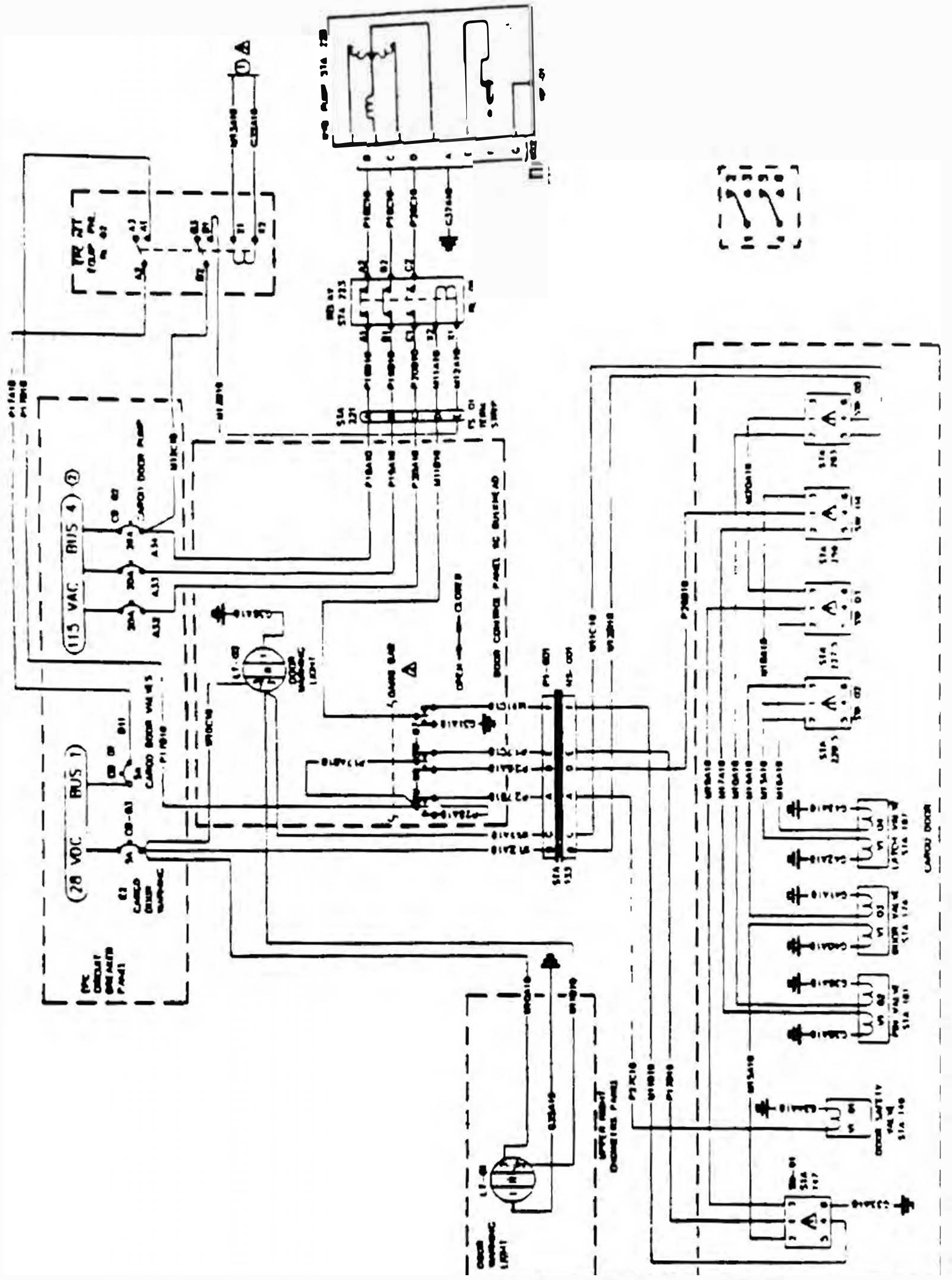


CARGO DOORS

Figure 1-33

(b) The 115 VAC, 400 cycle, 3-phase electrical power is supplied from BUSS #4, which is protected by one (20) AMP, 3 pole, circuit breaker located on the left side of the forward wall of the 9G bulkhead. The power is then directed to the relay. The relay is located in the left side of the forward lower cargo compartment and is energized by two different procedures.

1 The cargo door toggle switch, located on the left side of the forward wall of the 9G bulkhead, when in the up or open position, grounds the relay and causes it to be energized.

2 Microswitch (SW-01)) located on the upper forward corner of the cargo door, when in the normally closed position grounds the relay causing it to be energized.

(2) Warning System

The 28 VDC electrical power for the cargo door warning system, on some models, is supplied from BUSS #1 and is protected with a (5) AMP, single pole circuit breaker located on the EPC panel in the upper right corner. The power is directed three places from the circuit breaker; first to the warning light located on the upper right engineer's panel, for the press to test function, second to the warning light located on the 9G bulkhead, and third to microswitch (SW-05) located at the lower aft corner of the cargo door. When microswitch (SW-05) is actuated, a circuit is completed and the cargo door warning lights come "ON".

D. Opening and Closing Sequence - Upper Cargo Door

(1) Opening Sequence:

(a) The hydraulic pump pressurizes the system.

(b) Power is applied to the door safety valve (V1-01) through the door gang bar switch.

(c) Power is supplied to the pin valve (V1-02) through microswitch (SW-04). The port in pin valve opens, the hydraulic fluid is then directed to the pin cylinder. The pin cylinder retracts and microswitch (SW-04) actuates.

(d) Power is then directed to the latch valve (V1-04) through microswitch (SW-02). A port in the latch valve opens. The hydraulic fluid is then directed to the latch cylinder. The latch cylinder then retracts and microswitch (SW-02) actuates.

(e) Power is then directed to the cargo door valve (V1-03). The port in the cargo door valve opens. The hydraulic fluid is then directed to the cargo door cylinder and the cargo door cylinder retracts.

(2) Closing Sequence:

(a) Power is supplied to the cargo door safety valve (V1-01) and to cargo door valve (V1-03). The ports in the cargo safety valve and the cargo door open. Then the hydraulic fluid is allowed to return from the cargo door cylinder. The cargo door cylinder extends and the cargo door actuates microswitch (SW-01). The hydraulic pump will then begin to pressurize the system.

(b) Power is then directed to latch valve (V1-04) through microswitch (SW-03). A port in the latch valve opens. Then the hydraulic fluid is directed to the latch cylinder. The latch cylinder extends. microswitch (SW-03) is then actuated.

(c) Power is then directed to pin valve (V1-02) through microswitch (SW-05). A port in the pin valve opens. The hydraulic fluid is then directed to the pin cylinder, and the pin cylinder extends.

E. Description - AUX Hydraulic Hand Pump

The aircraft is equipped with an AUX Hydraulic hand pump which allows the door to be manually opened and closed. The AUX Hydraulic hand pump has the following components:

(1) Reservoir:

The system receives its supply of hydraulic fluid from a tank located overhead in forward courier compartment. The reservoir has a capacity of approximately one gallon.

(2) Hand Pump:

The hydraulic hand pump is located on the forward left hand side of the 9G bulkhead.

(3) Shut Off Valve:

The shutoff valve is located just below the reservoir. Close the shutoff valve and the door opens. Slowly open valve and the door closes.

CAUTION: IF DOOR IS OPENED MANUALLY, IT MUST BE CLOSED MANUALLY.

F. Operation

CAUTION: DO NOT TWO OR TAXI AIRPLANE WITH CARGO DOOR OPEN OR UNLATCHED.

DO NOT OPEN DOOR IF ACTUAL OR ANTICIPATED WIND VELOCITY WILL EXCEED 40 KNOTS, EXCEPT AS NOTED BELOW. DOOR MAY BE OPENED TO 85-DEGREE OF 130 DEGREE POSITIONS WITH MAXIMUM WIND VELOCITY OF 40 KNOTS (STEADY).

IF WIND VELOCITIES FROM 40 TO 50 KNOTS ARE ANTICIPATED, DOOR MAY BE OPENED TO 85 DEGREE POSITION, ONLY IF AIRPLANE IS PARKED SO THAT WIND DIRECTION IS AGAINST RIGHT SIDE OF AIRPLANE.

CAUTION: WIND VELOCITIES GREATER THAN 40 KNOTS DIRECTED AGAINST THE LEFT SIDE OF AIRPLANE, WILL BLOW CARGO DOOR FROM 85 DEGREE POSITION TO FULL OPEN OR BEYOND, THEREBY CAUSING DAMAGE TO FUSELAGE/CARGO DOOR.

(1) Forward Upper Cargo Door/Opening Procedure

(a) Ensure the following circuit breakers on the EPC circuit breaker panel are closed.

Circuit Breaker	Panel Location
Hydraulic Valves	28 VDC BUSS #1
Cargo Door Hyd Pump	3-Phase 115 VAC BUSS #4
Cargo Door Warning Lights	28 VDC BUSS #1

(b) Ensure cargo door area outside aircraft is clear.

(c) Place toggle switch in open position and hold, at the same time push hydraulic safety lever aft and hold until door opens.

(d) Ensure lockpins disengage from latches.

(e) When cargo door reaches full open position, release toggle switch and hydraulic safety lever, and place cargo door safety hook in lock position.

(f) Cargo door warning lights on engineer's panel and 9G bulkhead should come "ON".

(2) Forward Upper Cargo Door/Closing Procedure

(a) Verify that the cargo door hyd pump, hydraulic valves and cargo door warning light circuit breakers are closed.

(b) Move cargo door safety hook to unlocked position.

(c) Place toggle switch in closed position and hold, at the same time push hydraulic safety lever to aft position and hold until door closes.

NOTE: Hydraulic pump will not begin to operate until the door nears the closed position.

(d) Ensure lockpins are engaged in latches.

(e) Ensure black and white strips on latch assemblies are in alignment.

(f) Verify cargo door warning lights on engineer's panel and 9G bulkhead are "OFF".

G. AUX Hydraulic Hand Pump - Operations

(1) Open Procedure

(a) Ensure the following circuit breakers on the EPC circuit breaker panel are opened.

Circuit Breaker	Panel Location
Hydraulic Valves	28 VDC BUSS #1
Cargo Door Hyd Pump	3-Phase 115 VAC BUSS #4
Cargo Door Warning Lights	28 VDC BUSS #1

WARNING: TAG AND SAFETY CIRCUIT BREAKERS.

(b) Using manual open wrench, located on the left side of the cargo compartment at STA 120 (waist level painted red).

(c) Disconnect the pin cylinder from U-bar; reinsert pin cylinder bolt in U-bar. Take the manual open wrench, insert the hook end to the pin cylinder bolt, and pull U-bar forward to disengage pins.

(d) Close shutoff valve located above the hand pump inside 9G bulkhead.

(e) Pump the hand pump while holding toggle switch in open position, until door is open and safety latch is engaged.

NOTE: If electrical power is not available the cargo door control valve slide will need to be manually centered by pushing the Red Tabs to prevent a hydraulic lock of door actuating cylinder.

CAUTION: IF DOOR IS OPENED MANUALLY, IT MUST BE CLOSED MANUALLY.

(2) Closing Procedure

(a) Verify that the cargo door hyd pump, hydraulic valves and cargo door warning light circuit breakers are opened.

(b) Slowly open shutoff valve, located above hand pump, until cargo door is closed.

(c) Insert manual open wrench into the hook end of the pin cylinder bolt, then push the U-bar aft to engage lockpins.

(d) Remove wrench and bolt, then re-install pin cylinder bolt to U-bar.

(e) Ensure lockpins are engaged by looking inside or through the inspection window, located on outside of cargo door in lower aft corner.

21. Service Doors - Description and Operation

A. General

(1) The DC-8, aircraft are equipped with plug-type service doors in the forward, center, and aft section of the fuselage. The number and location of the service doors are dependent upon the configuration of the airplane. The doors provide access to the upper cargo compartment, the air-conditioning, and accessory compartments. The service doors are similar in construction and operation. The essential difference between the doors is the control mechanism in the left center door.

(2) The doors for the air-conditioning and accessory compartments are located on the lower centerline of the airplane. The doors are similar in construction and operation.

An external door is not provided for the accessory compartment of all airplanes. Access to the accessory compartment of airplane not provided with an accessory compartment door on the lower centerline of the airplane is provided through access door No. 692 located in the aft bulkhead of the forward lower cargo compartment.

B. Description

(1) (See Figures 1-34 and 1-35) all cabin compartment service doors have been deactivated with the exception of the RH AFT service door which remains operable. The service doors were deactivated by Engineering authorization. The deactivation was accomplished by removing the bayonet, bayonet fittings, inside door handle, and installing attachment plates, bolts, and safety wires.

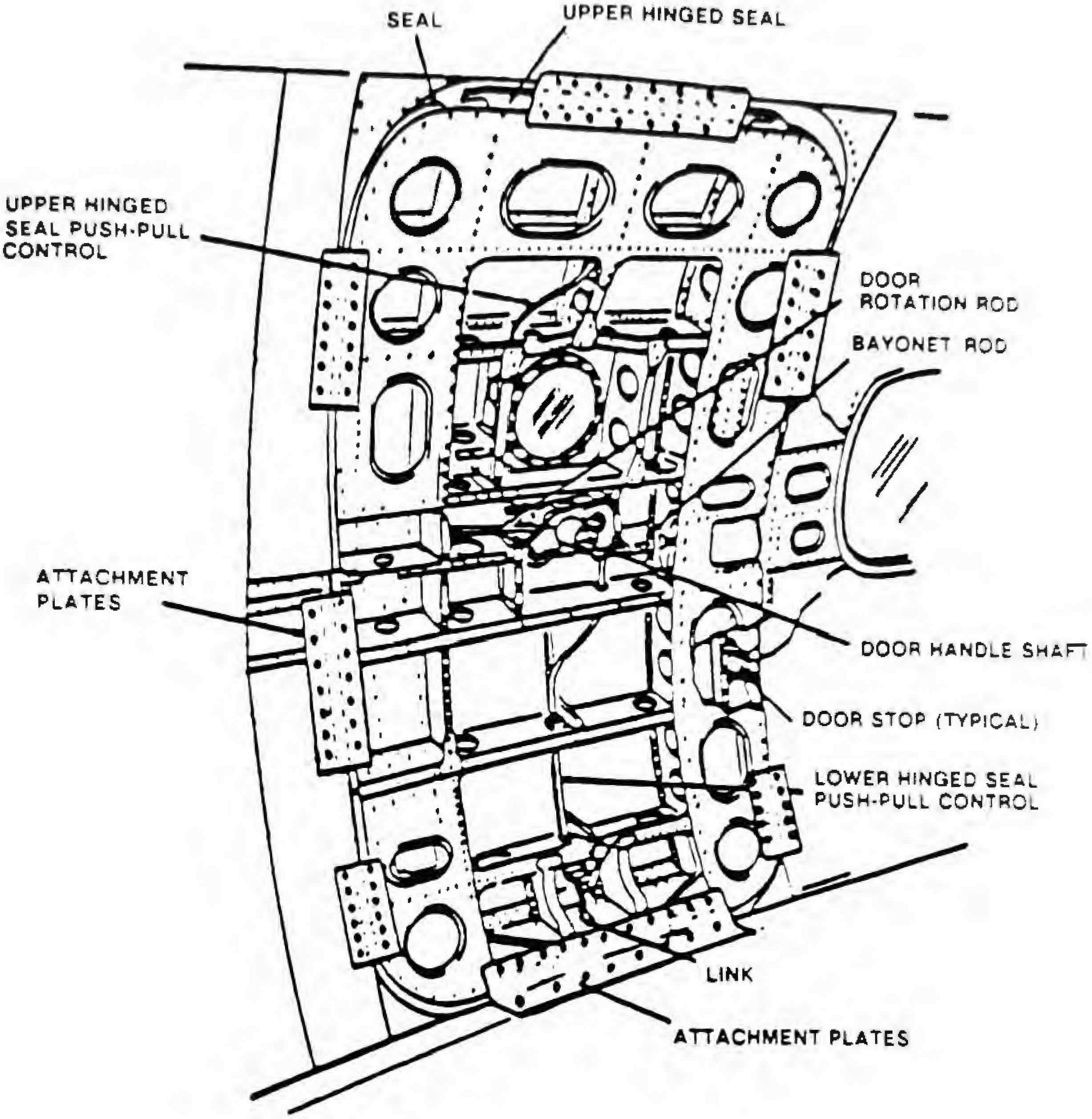
(2) RH AFT Service Door (See Figures 1-36 and 1-37)

(a) The doors are approximately 33 1/2 inches wide by 64 inches high and consist of beams, intercostals, doublers, pans, skins, and fittings. In addition, each door contains a mechanism for opening and closing the door, retracting and extending the hinged sections of the pressure seal installed along the upper and lower edges of the door, and for holding the door in the open position. The door is attached to the fuselage structure by hinges. The shape and installation of the hinges permit inward, forward, and outward movement of the door. The hinges are attached to the door and the doorjamb by torque tubes.

(3) A trim and acoustic seal and a pressure seal are installed on each door. The trim and acoustic seal, made of dacron impregnated with silicone rubber, is attached to the door lining. The pressure seal is constructed of silicone rubber sheets with a filler of sponge rubber. The seal is attached to the edge of the doorframe by retainers which are secured to the doorframe by screws. A seal depressor on the doorjamb contacts the seal when the door is closed. Adjustable doorstops on the doorjamb provides the means for fairing the door with the fuselage and assure firm contact of the seal depressor with the pressure seal.

(4) A window is installed in the upper section of each door to permit viewing the area adjacent to the door for obstructions before opening the door. The window installation consists of two panes of glass with an airspace between the panes to prevent fogging of the window.

(5) The doors can be opened from either inside or outside the airplane by handles attached to a common shaft. Rotating either handle actuates the door opening mechanism. An assist handle is attached to the



FORWARD & RIGHT CENTER DEACTIVATED SERVICE DOORS

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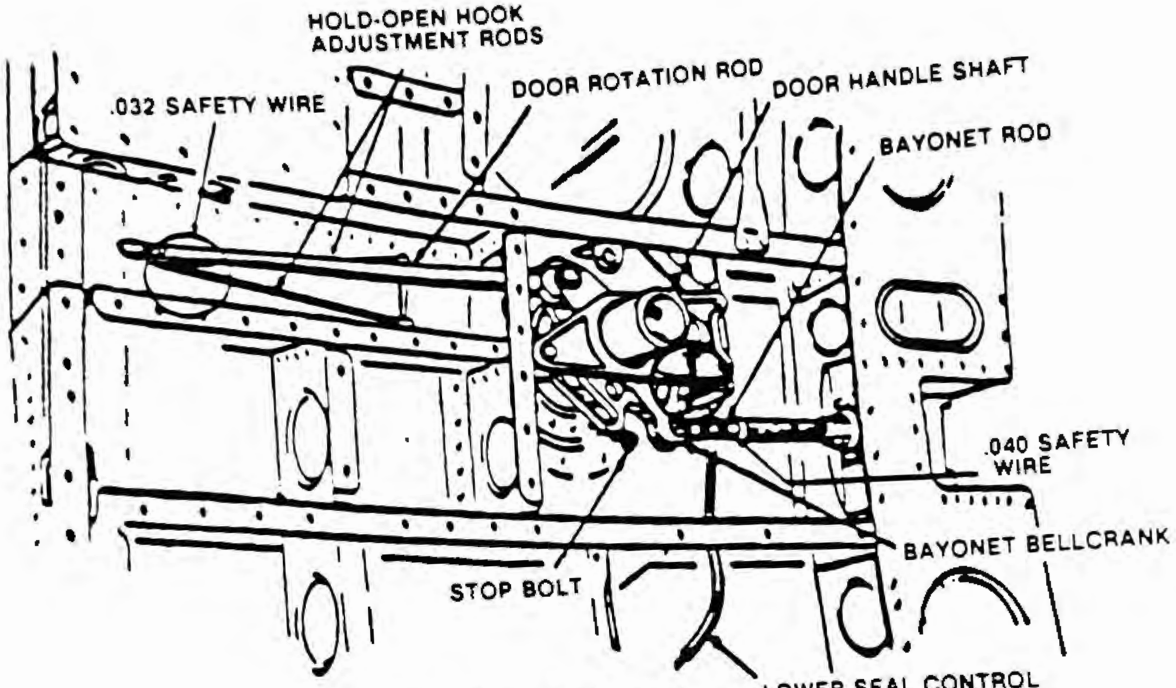
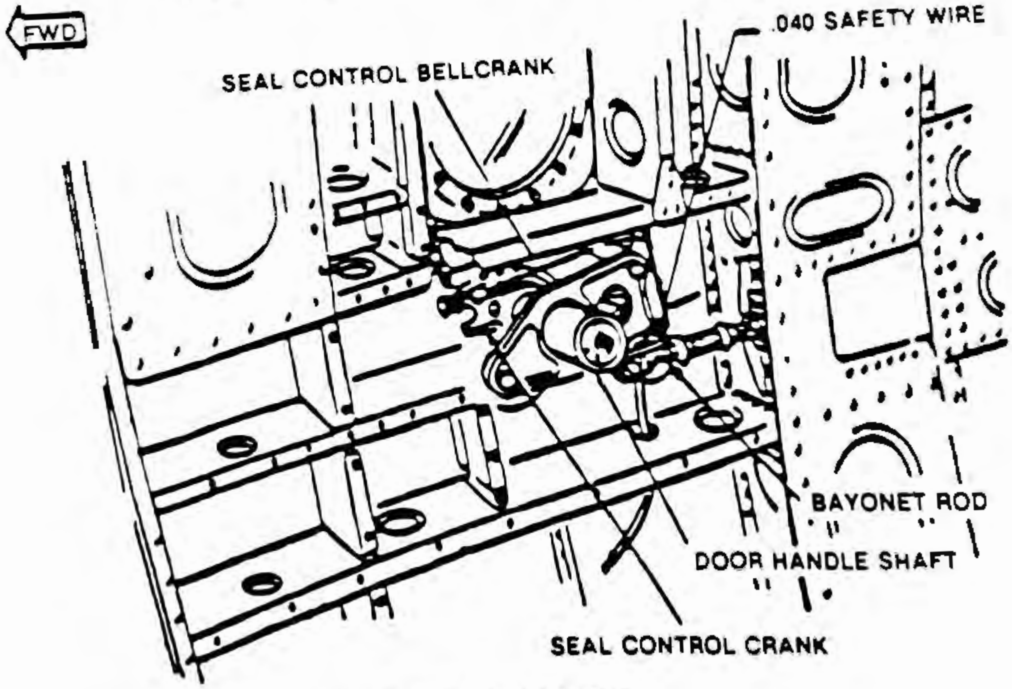
Figure 1-34



DOOR IN OPEN POSITION

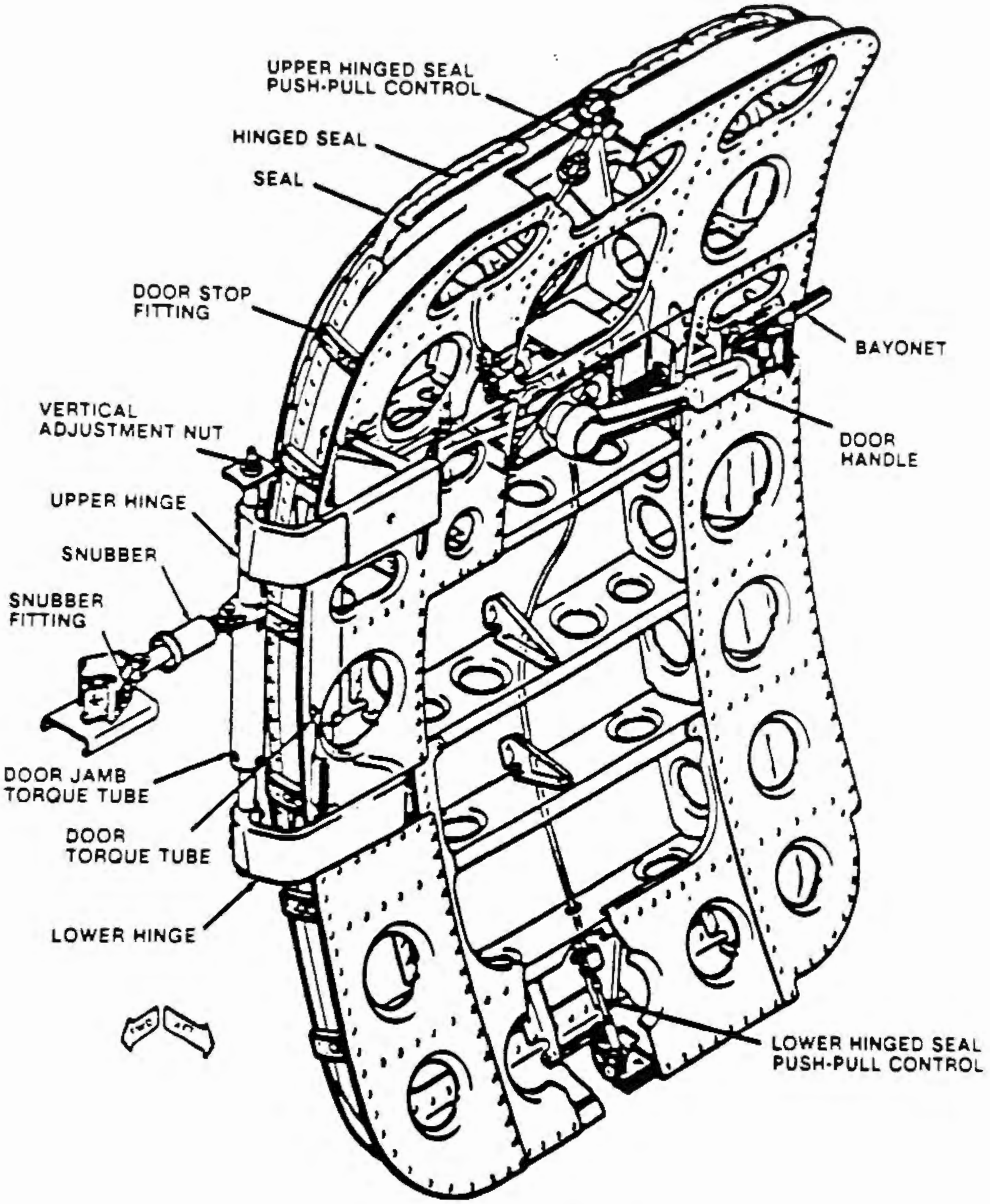


DOOR IN CLOSED POSITION

FORWARD & RIGHT CENTER DEACTIVATED SERVICE DOORS

FTX80675

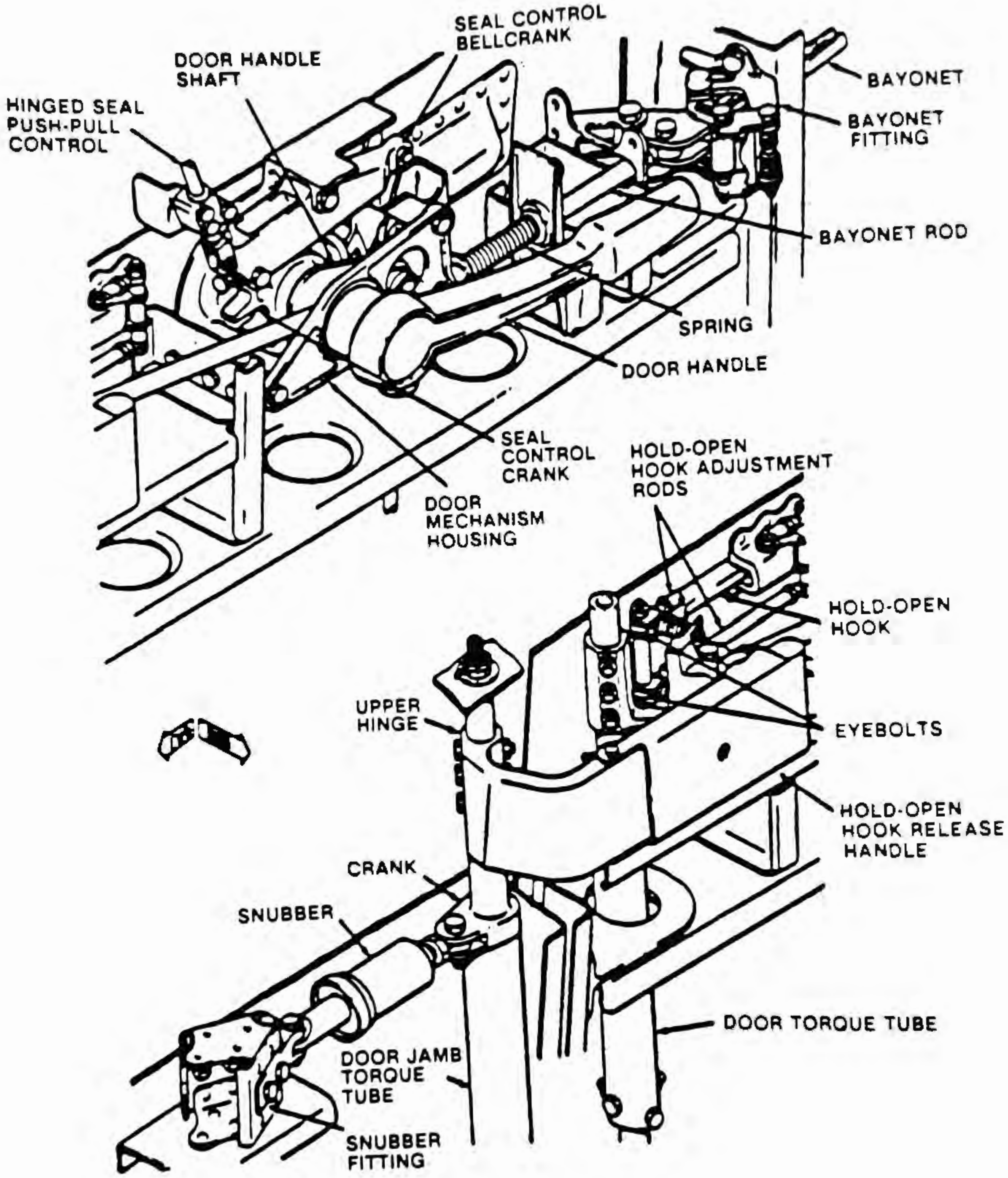
Figure 1-35



AFT SERVICE DOOR

FTX80677

Figure 1-36



AFT SERVICE DOOR

FTX80678

Figure 1-37

inside of the door to aid in opening and closing the door. A snubber attached to the hinge torque tube, installed in the doorjamb, and the fuselage structure protects against either wind gusts or personnel slamming the door against the fuselage or doorjamb. A hold-open fitting in the side of the fuselage to hold the door parallel to the inside of the fuselage when the door is opened.

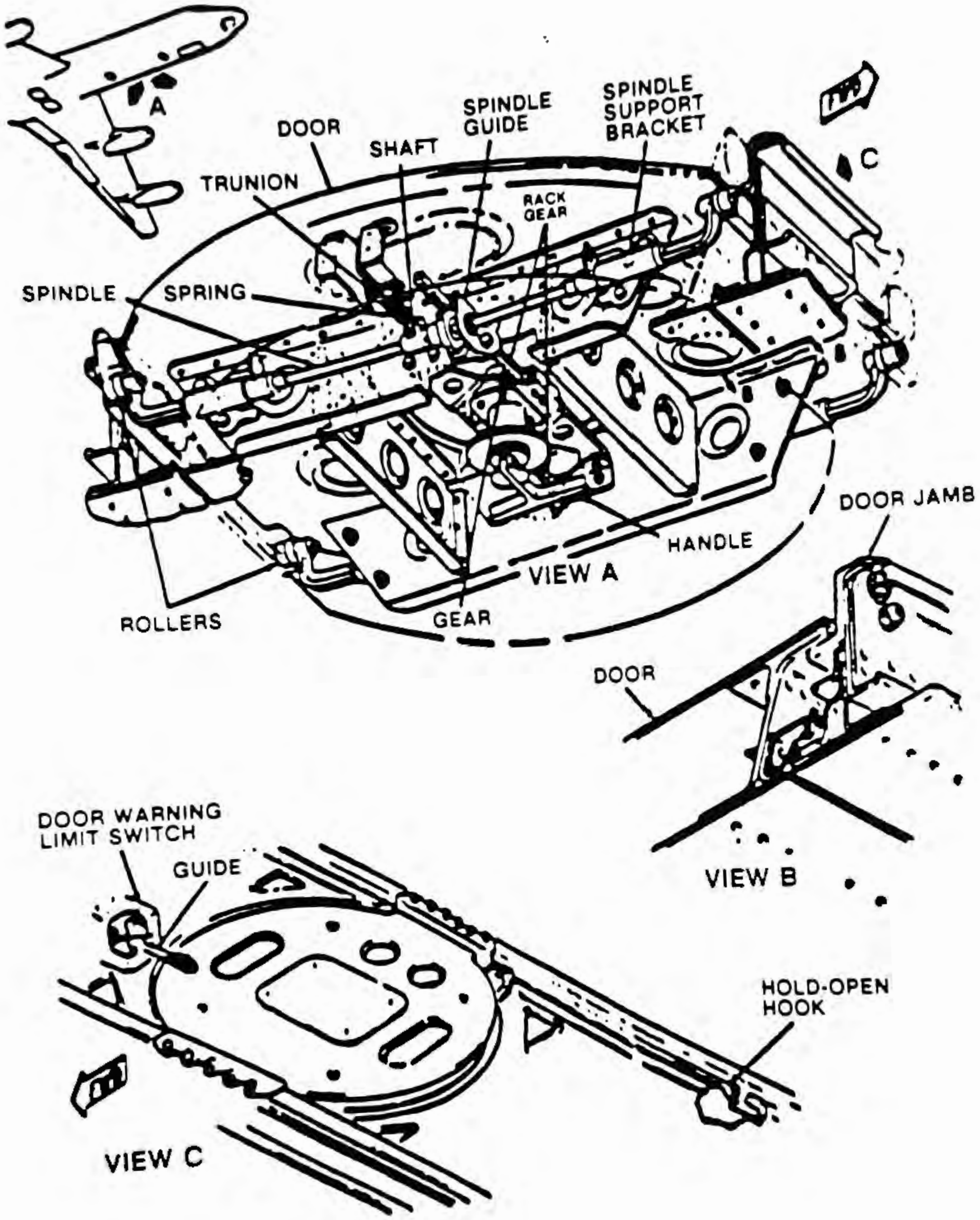
(6) A lining is installed on the inner surface of each service door. The lining serves as a vibration, heat, and sound insulator, and a protection for the door-operating mechanisms. The lining consists of a fiberglass blanket enclosed by nylon cloth panels, and hardwood blocking for the installation of attachments. A window assembly installed in the upper section of the lining mates with the window installed in the door structure. The lining is attached to the door structure by vibration isolators, and a weather seal is attached to the outer edge of the lining.

(7) The door warning limit switch has been removed from the deactivated service doors, with exception of the RH aft service door. A door warning limit switch is installed in the forward section of the doorjambs of the service doors. A striker attached to the door actuates the limit switch. When the door is closed, the switch opens a ground circuit to the door warning indicating light in the flight compartment, and the light goes off. When the door is opened, the limit switch closes the ground circuit to the warning light and the light comes on.

C. Air Conditioning and Accessory Compartment Doors (See Figure 1-38)

(1) The doors for the air conditioning and accessory compartment doors are approximately 16 x 19 inches in size. The doors open upward and slide outboard on tracks attached to the fuselage structure. The door consists of a pan, inner and outer skins, stiffeners, doublers, fittings, a pressure seal, and a mechanism for opening and closing the door.

(2) The pressure seal is constructed of silicone rubber sheet and is attached to the doorframe by retainers and supports which are secured to the doorframe by screws. A seal depressor on the doorjamb contacts the seal when the door is closed. Adjustable brackets on the forward and aft edges of the door provide the means for fairing the door with the fuselage and assure firm contact of the seal depressor with the pressure seal.



AIR CONDITIONING AND ACCESSORY COMPARTMENT DOORS

FTX80679

Figure 1-38

(3) The door mechanism consists of gears, spindles, shafts, springs, trunnions, and track rollers. The mechanism is actuated by a handle located in a well in the outer skin. When the door is closed and latched, the handle is flush with the outer skin. The door is held in the open position by a hold-open hook which engages one of the track rollers when the door is opened.

(4) A door warning limit switch is installed in the doorjambs of the air conditioning and accessory compartment doors. An adjustable guide installed on the door actuates the limit switch. When the door is closed, the switch opens a ground circuit to the door warning indicating light in the flight compartment and the light goes off. When the door opened, the limit switch closes the ground circuit to the warning light and the light comes on.

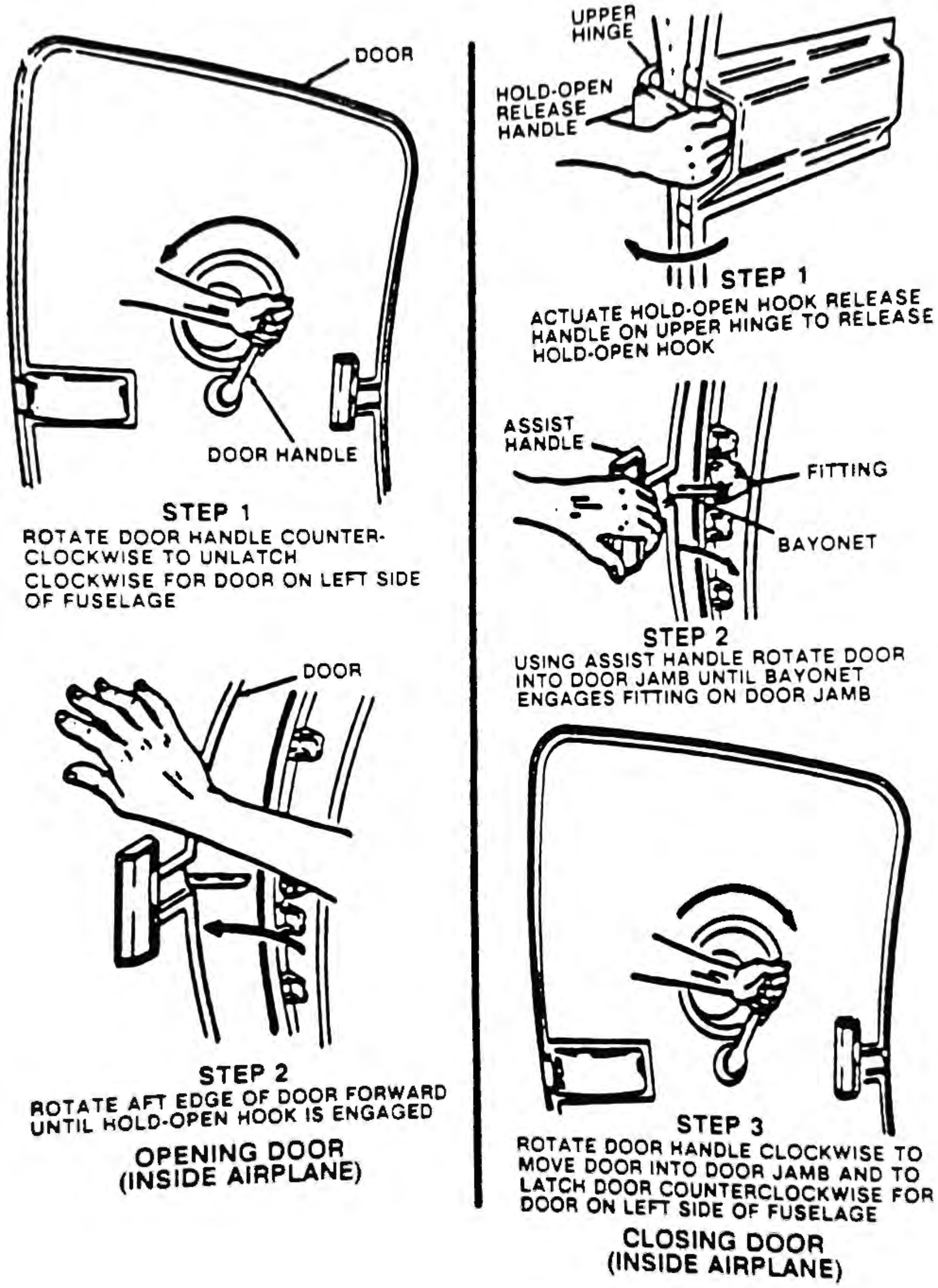
D. Operation

(1) Cabin Compartment Service Doors (See Figure 1-39 and 1-40)

CAUTION: **DO NOT ATTEMPT TO OPEN DOOR WHEN AIRPLANE IS PRESSURIZED.**

NOTE: **Before opening the door from inside the airplane, look through the door window to make certain that area adjacent to the door is clear of obstructions.**

(a) Opening the doors on the right side of the fuselage is accomplished by rotating the inner door handle counterclockwise (outer handle clockwise). As the handle is rotated, the door rotation rod, attached to the door handle shaft and the upper hinge, moves forward to rotate the hinges inward and forward. The hinges carry the door inward and forward far enough to allow the door to be pushed edgewise through the door opening. Simultaneously, the seal control bellcrank is repositioned to actuate the hinged seals push-pull controls to retract the upper and lower hinged seals which permit the door to pass through the door opening in the fuselage. At the same time, the bayonet bellcrank is released from the hook on the door handle shaft cam to allow the spring-loaded bayonet rod to rotate the bayonet inward so that the bayonet will clear the doorjamb as the door is rotated through the door opening. When the door handle reaches full travel, the cam



STEP 1
ROTATE DOOR HANDLE COUNTER-CLOCKWISE TO UNLATCH
CLOCKWISE FOR DOOR ON LEFT SIDE OF FUSELAGE

STEP 2
ROTATE AFT EDGE OF DOOR FORWARD UNTIL HOLD-OPEN HOOK IS ENGAGED

OPENING DOOR
(INSIDE AIRPLANE)

STEP 1
ACTUATE HOLD-OPEN HOOK RELEASE HANDLE ON UPPER HINGE TO RELEASE HOLD-OPEN HOOK

STEP 2
USING ASSIST HANDLE ROTATE DOOR INTO DOOR JAMB UNTIL BAYONET ENGAGES FITTING ON DOOR JAMB

STEP 3
ROTATE DOOR HANDLE CLOCKWISE TO MOVE DOOR INTO DOOR JAMB AND TO LATCH DOOR COUNTERCLOCKWISE FOR DOOR ON LEFT SIDE OF FUSELAGE

CLOSING DOOR
(INSIDE AIRPLANE)

AFT SERVICE DOOR - OPERATION

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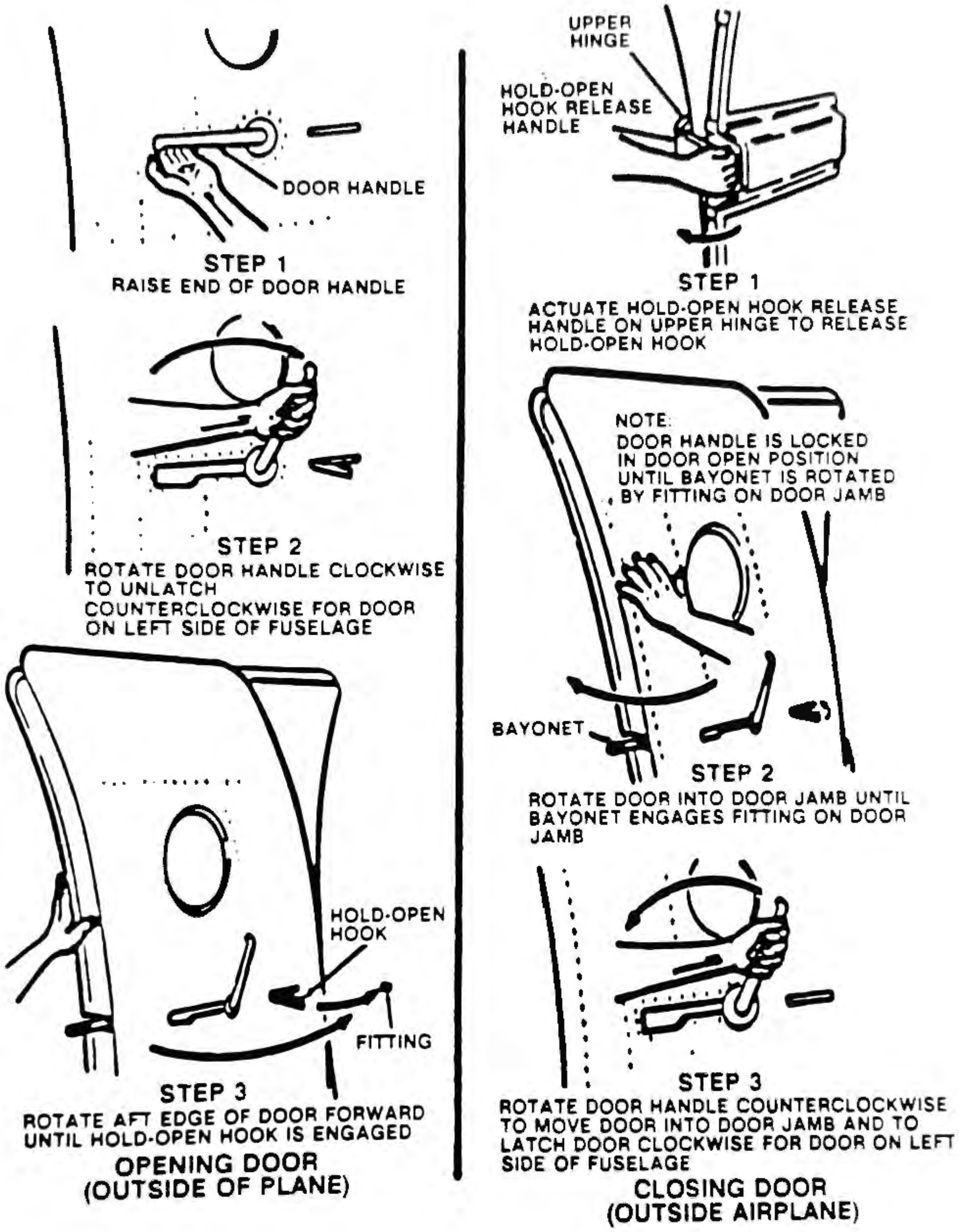
Figure 1-39



STEP 1
RAISE END OF DOOR HANDLE

STEP 2
ROTATE DOOR HANDLE CLOCKWISE TO UNLATCH
COUNTERCLOCKWISE FOR DOOR ON LEFT SIDE OF FUSELAGE

STEP 3
ROTATE AFT EDGE OF DOOR FORWARD UNTIL HOLD-OPEN HOOK IS ENGAGED

OPENING DOOR
(OUTSIDE OF PLANE)

STEP 1
ACTUATE HOLD-OPEN HOOK RELEASE HANDLE ON UPPER HINGE TO RELEASE HOLD-OPEN HOOK

NOTE:
DOOR HANDLE IS LOCKED IN DOOR OPEN POSITION UNTIL BAYONET IS ROTATED BY FITTING ON DOOR JAMB

STEP 2
ROTATE DOOR INTO DOOR JAMB UNTIL BAYONET ENGAGES FITTING ON DOOR JAMB

STEP 3
ROTATE DOOR HANDLE COUNTERCLOCKWISE TO MOVE DOOR INTO DOOR JAMB AND TO LATCH DOOR CLOCKWISE FOR DOOR ON LEFT SIDE OF FUSELAGE

CLOSING DOOR
(OUTSIDE AIRPLANE)

AFT SERVICE DOOR - OPERATION

FTX80680

Figure 1-40

follower on the bayonet bellcrank engages a detent on the door handle shaft to lock the door handle in the door open position. As the door hinges are rotated, the hold-open hook is rotated into position to engage the fitting in the side of the fuselage. When the door is fully open, the hook is engaged and the door is held in the open position.

CAUTION: MAKE CERTAIN THAT HOLD-OPEN HOOK IS ENGAGED WHEN DOOR IS OPEN TO PREVENT POSSIBLE DAMAGE FROM WIND GUSTS SLAMMING DOOR AGAINST FUSELAGE OR DOORJAMB.

NOTE: The upper and lower hinged seals on the left center service door are actuated by cranks and push-pull rods.

(b) Closing the door is accomplished by pulling on the hold-open hook release handle, which is located on the upper hinge, to release the hold-open hook. The door is then pulled inward through the door opening and aft until the bayonet engages the bayonet fitting on the doorjamb (after the door is pulled inside the fuselage, the assist handle is used to guide the door). Rollers on the bayonet fitting force the bayonet outward, which moves the bayonet rod forward and rotates the bayonet bellcrank cam follower out of the hook of the door handle shaft cam to allow the door handle to be rotated. Rotating the inner door handle of doors on the right side of the fuselage clockwise (outer handle counterclockwise); moves the door hinges aft and outward to position the door in the doorjamb, and retract the hold-open hook. As the handle is rotated, the upper and lower hinged seals are extended. When the handle reaches its full travel, the door rotation rod is forced overcenter in the door handle shaft to lock the door hinges, and the cam follower on the bayonet bellcrank engages the hook of the door handle shaft cam to lock the bayonet. The door is held securely in the closed position by engagement of the bayonet with the bayonet fitting on the doorjamb, the overcenter condition of the door rotation rod, and the engagement of the cam follower on the bayonet bellcrank with the hook on the door handle shaft cam. This prevents the door from being forced inward by air loads prior to pressurization of the passenger compartment.

(2) Air Conditioning and Accessory Compartment Doors

(a) To open the door, the door handle is rotated downward out of the door handle well. The door handle is then rotated one complete revolution and placed in its original (stowed) position in the door handle well. This action, through gears, shafts, and rollers. raise the door clear of the doorjamb. When the door is in the full up position, the door is pushed outboard on rollers which are guided by the tracks installed on the fuselage structure until the hold-open hook is engaged.

(b) The door is closed by pulling the door inboard until the guide on the door contacts the stop on the doorjamb. The door handle is rotated out of the well and then rotated one complete revolution and placed in its original (stowed) position.

22. Door Warning - Description and Operation

A. General

The door warning system provides the flight crew with visual indication when any of the pressure compartment external doors are open.

B. Description

(1) The door warning system has limit switches that are installed in the doorjambs of the cabin and service doors, lower cargo doors, air-conditioning door, and accessory door (if equipped). The limit switches control a red press-to-test indicating light installed on the engineer's panel, and is divided into two parts. One light is placarded CABIN DOOR OPEN and the other light, BELLY DOOR OPEN. In addition to the CABIN and BELLY DOOR OPEN warning lights, there are annunciator lights on FE panel. When the limit switch for an individual door is actuated, a specific annunciator light will illuminate.

(a) Upper Cargo Door Switch Location

1 (Douglas)

The upper cargo door has three limit switches and one proximity switch. The limit switches are installed in the doorjamb, the No. 6 latch position, and the vent door. The proximity switch is installed on the lockpin at Latch No. 2.

2 (R.A.I.)

The forward upper cargo door is provided with a microswitch installed at the lockpin walking beam position located at the aft corner of the cargo door.

(2) The door warning system is divided into three circuits. One circuit contains the limit switches for the cabin and service doors, and operates the CABIN DOOR OPEN light. The second circuit contains the limit switches for the lower cargo compartments, the air-conditioning, and the accessory compartment doors (if equipped) and operates the BELLY DOOR OPEN light. The third circuit contains the annunciator light panel, each light in the panel is identified individually by door position and will illuminate when the specific door is opened.

(a) Upper Cargo Door Warning Circuits

1 (Douglas)

The upper cargo door warning system is divided into two circuits. One circuit contains the limit switches which are included in the cabin and service door warning, and the master warning system. The CABIN DOOR OPEN, and the MAIN CARGO SYSTEM A indicating lights are operated through this circuit. The other circuit contains the proximity switch which operates the MAIN CARGO DOOR SYSTEM B indicating light on the engineer's panel, and is not included in the master warning system.

2 (R.A.I.)

The upper cargo door has an independent warning circuit. The circuit contains a microswitch that operates a light on the 9G bulkhead and a light on the engineer's panel.

(3) The limit switches for the cabin and service doors, lower cargo compartment (non-cross-slide) doors, air-conditioning door, and accessory compartment door (if equipped) are actuated by strikers installed on the doors. With exception of the strikers on the air-conditioning and accessory compartment doors, which are adjustable, all the limit switches are the override type and require no adjustment. The limit switches for the lower cargo cross-slide doors are actuated by the center latchpin of the latching mechanism.

(a) Upper Cargo Door Switches

1 (Douglas)

The limit switch for the vent door is actuated by the opening of the vent door. The limit switch at No. 6 latch is actuated by the lockpin for No. 6 latch. The proximity switch is triggered when the lockpin moves toward the face of the sensor of the proximity switch. The limit switch in the doorjamb of the upper cargo door is actuated by the lower edge of the door.

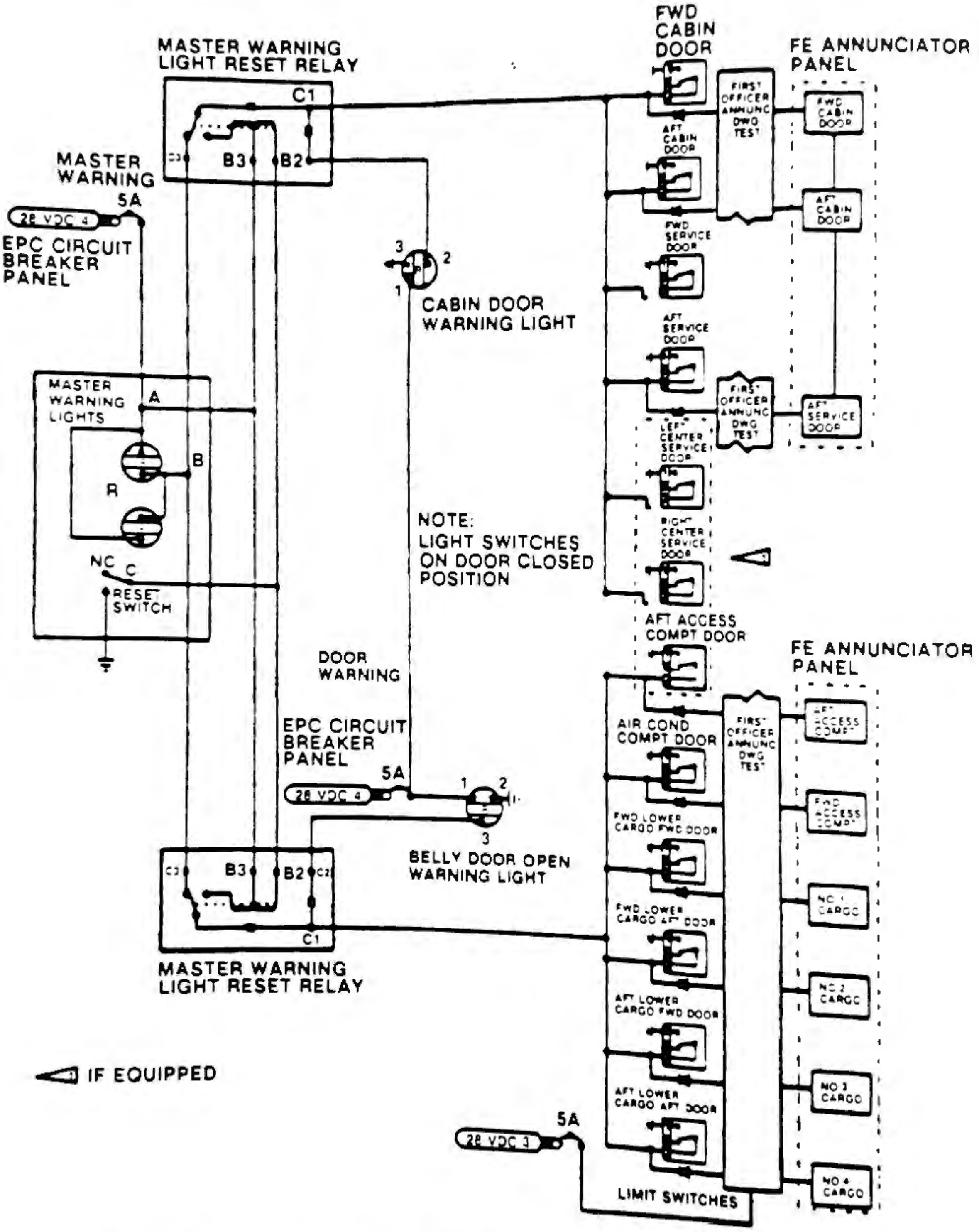
2 (R.A.I.)

The microswitch for the upper cargo is actuated by the lockpin walking beam.

(4) The door warning systems receives 28 VDC power through the door warning circuit breakers on the EPC circuit breaker panel.

C. Operation (See Figure 1-41)

(1) When a cabin or service door is opened, the limit switch for that door completes the ground circuit to the CABIN DOOR OPEN, the FWD CABIN DOOR, or AFT SERVICE DOOR annunciator light, causing the lights to come on. When the cabin or service doors are closed, the CABIN DOOR OPEN, the FWD CABIN DOOR, or AFT SERVICE DOOR annunciator lights will go out.



DOOR WARNING SYSTEM SIMPLIFIED SCHEMATIC

Figure 1-41

FTX80682

(a) Upper Cargo Door Operation

1 (Douglas) (See Figure 1-42)

With the upper cargo door and vent door included in the cabin and service door warning system, the limit switches and proximity switch are actuated as follows:

a The vent door limit switch is actuated by the opening of the vent door. This completes a ground circuit to the CABIN DOOR OPEN light and to the MAIN CARGO DOOR SYSTEM A, light on the engineer's panel.

b When the lockpins are disengaged from the latches the limit switch at No. 6 latch is actuated and completes a ground circuit to the CABIN DOOR OPEN light.

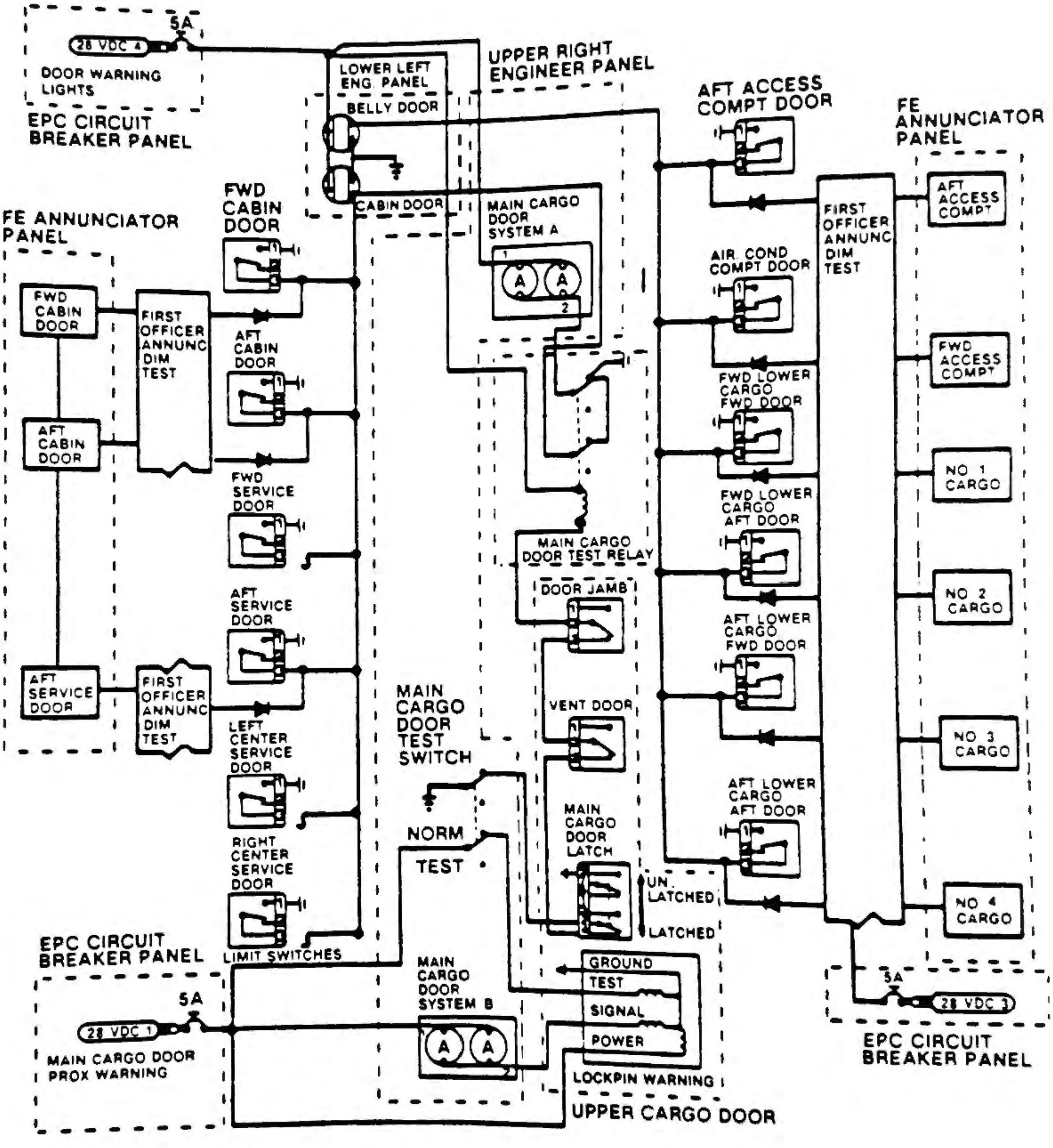
c The proximity switch for the lockpin is triggered when the lockpin actuates toward the face of the sensor of the proximity switch. This completes a ground circuit to the MAIN CARGO DOOR SYSTEM B light on the engineer's panel.

d A limit switch located in the doorjamb of the upper cargo door is actuated by the opening of the cargo door. This completes a ground circuit to the CABIN DOOR OPEN light.

e The MAIN CARGO DOOR SYSTEM A and MAIN CARGO DOOR SYSTEM B lights and the CABIN DOOR OPEN light will remain on until the cargo door is closed, the latches are closed and latched, the pins engage the latches, and the vent door is closed.

2 (R.A.I.) (See Figure 1-43)

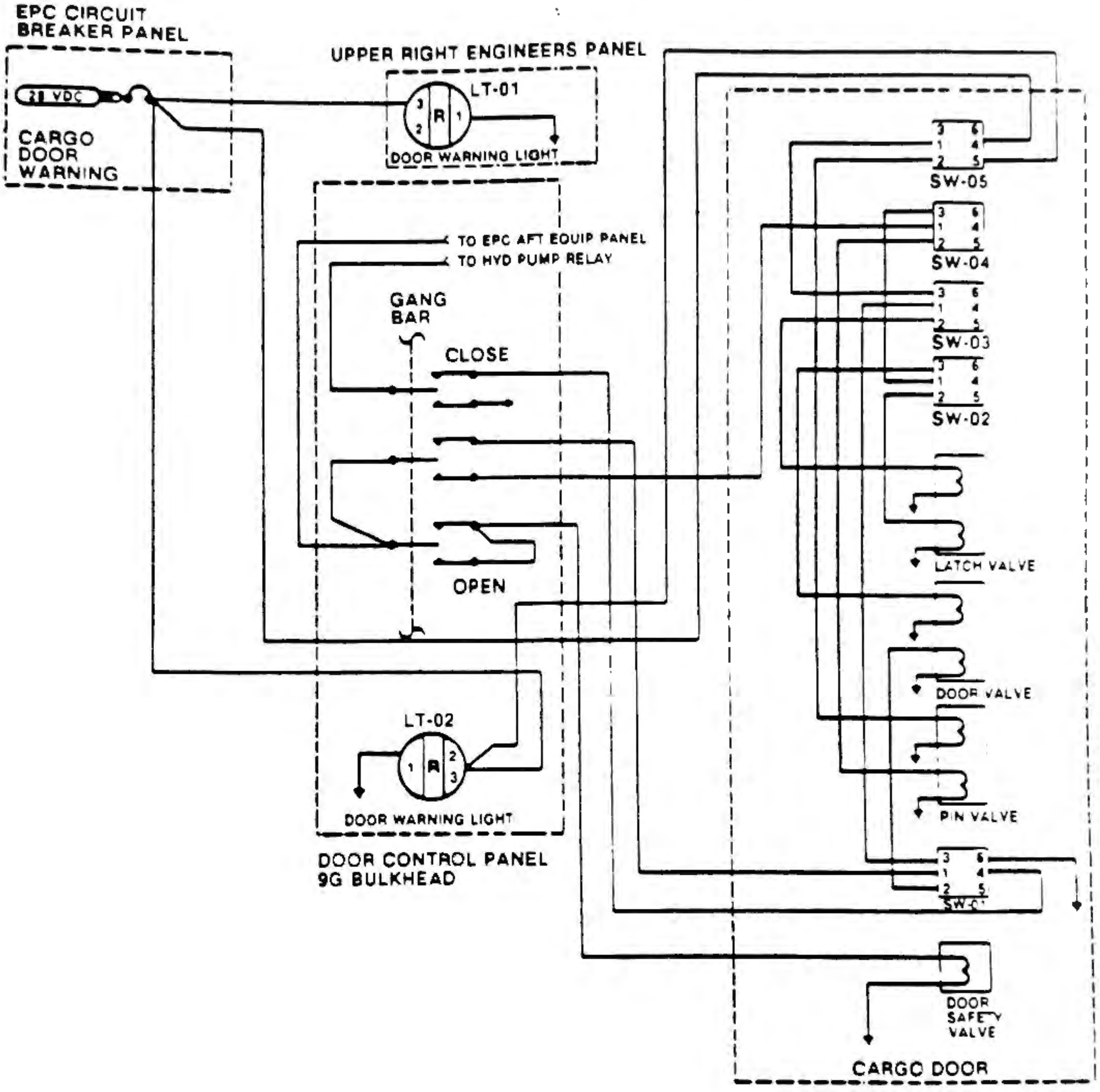
a When the upper cargo door opens, the microswitch is actuated by the lockpins disengaging from the latches, completing the ground circuit to the warning lights on the 9G bulkhead and the engineer's panel.



DOOR WARNING SYSTEM SIMPLIFIED SCHEMATIC

Figure 1-42

FTX80683



DOOR WARNING SYSTEM SIMPLIFIED SCHEMATIC

FTX80684

Figure 1-43

(1) When a door to the forward or aft lower cargo compartments, air-conditioning compartment, or accessory compartment (if equipped) are opened,the limit switch for that door completes the ground circuit to the BELLY DOOR OPEN, and the specific annunciator light for the individual door, causing the lights to come on. When a door to the FWD or AFT LOWER CARGO compartments, air-conditioning compartment, or accessory compartment (if equipped) are closed, the BELLY DOOR OPEN and the specific annunciator light for the individual door will go out.

(2) Master Warning Light

(a) (Douglas)

In addition to the door warning indicating lights, the master warning light comes on when any of the compartment doors, including the upper cargo door and vent door (if equipped) are opened. When a door is opened, the limit switch for that door completes a ground circuit to the master warning light on the glareshield, causing the light to come on. The light remains on until all the doors are closed or the master warning light reset switch is actuated.

(b) (R.A.I.)

The master warning light comes on when any of the compartment doors are opened, with exception of the upper cargo door, which has an independent warning light system. When a door is opened,the limit switch for that door completes a ground circuit to the master warning light on the glareshield. The warning light will remain on until all the doors are closed, with the exception of the upper cargo door, or the master warning light reset switch is actuated.

23. Auxiliary Door Warning - Description and Operation

A. General

The system consists of five aerospace optics annunciators located on the Flight Engineer's upper right instrument panel which are connected to each aircraft exterior door, a diode isolation board located above the cockpit entry area, a five amp circuit breaker, and two leach plug in relays located in the aft EPC equipment panel (back side of the radio rack).

B. Operation

There is a microswitch at each door which is grounded when the associated door is unlocked thereby annunciating which door is open. The annunciators may be tested by pressing the Flight Engineer's annunciator test button located at the top of his upper right instrument panel.

C. Auxiliary Door Warning - Adjustment/Test

(1) Apply buss power to aircraft.

(2) Close all exterior aircraft doors.

(3) Press Flight Engineer's annunciator test button and ensure all door warning annunciators light.

(4) Open one door at a time and ensure appropriate annunciator illuminates and then close the door.

(5) Repeat Step 4 for each aircraft exterior door.

NOTE: The following dimensions, angles, and areas are approximate and are measured in planes parallel or perpendicular to the fuselage reference plane.

24. DC-8-61

A. Wing Group

Span:

Wing (overall)	142 ft. 4.3 in.
Ailerons (each side)	24 ft. 0 in.
Flaps (each side)	33 ft. 9.7 in.

Areas:

Wing (total, including ailerons, flaps, and area within the fuselage)	2883.6 sq. ft.
Ailerons (total, both sides, excluding balance area forward of hinge line but including 23 square feet of tab area aft of tab hinge line)	161.6 sq. ft.
Flaps (total)	456.9 sq. ft.

Dihedral (at trailing edge)	6.5 deg.
Sweepback (25% chord line)	30.6 deg.
Aspect ratio	7.0
MAC	789.7
Leading Edge (at fuselage) Station	275.9 in.
Taper ratio	0.230
Flap maximum deflection	50.0 deg.

B. Horizontal Tail Surfaces

Span	47 ft. 6 in.

Areas:

Horizontal surfaces (total, including area within fuselage)	559.1 sq. ft.
Stabilizer (excluding elevator and overhanging elevator balance but including area within fuselage)	391.2 sq. ft.
Elevators (total, including 42.5 square feet of balance area forward of hinge line and including 20.9 square feet of total tab area aft of tab hinge line)	167.9 sq. ft.

Dihedral	10 deg.

Incidence (variable)	-10 to 2.0 deg
Sweepback (25% chord line)	35 deg
Aspect ratio	4.0
Taper ratio	0.329

C. Vertical Tail Surfaces

Span	25 ft. 11 in
Aspect ratio	1.9
Taper ratio	0.299
Sweepback (25% chord line)	35 deg

Areas:

Vertical tail (total, excluding dorsal fin but including area within fuselage)	351.7 sq ft
Rudder (including 34.4 square feet of balance area forward of hinge line and 8.1 square feet of tab area aft of tab hinge line)	128.8 sq ft

D. Fuselage

Height (maximum cross section)	13 ft. 4.5 in
Width (maximum cross section)	12 ft. 3 in.
Overall length	187 ft. 5 in

E. Landing Gear

Main	
Tread	20 ft. 10 in.
Wheel base	57 ft. 5.9 in.
Tires	44 x 16 in.
Nose Tires	34 x 11 in.
Maximum Nosewheel steering angle	74.5 deg.
Width required for 180-degree turn	112.5 ft.

25. DC-8-62

A. Wing Group

Span:

Wing (overall)	148 ft. 5 in.
Ailerons (each side)	24 ft. 0 in.
Flaps (each side)	33 ft. 10 in.

Areas:	
Wing (total, including ailerons, flaps, and area within the fuselage)	2926.8 sq. ft.
Ailerons (total, both sides, excluding balance area forward of hinge line but including 23 square feet of tab area aft of tab hinge line)	161.6 sq. ft.
Flaps (total)	456.9 sq. ft.
Dihedral (at trailing edge)	6.5 deg.
Sweepback (25% chord line)	30.6 deg.
Aspect ratio	7.52
MAC	795.8
Leading Edge (at fuselage) Station	272.8 in.
Taper ratio	0.197
Flap maximum deflection	50.0 deg.

B. Horizontal Tail Surfaces

Span	47 ft. 6 in.
Areas:	
Horizontal surfaces (total, including area within fuselage)	559.1 sq. ft.
Stabilizer (excluding elevator and overhanging elevator balance but including area within fuselage)	391.1 sq. ft.
Elevators (total, including 42.5 square feet of balance area forward of hinge line and including 20.9 square feet of total tab area aft of tab hinge line)	167.9 sq. ft.
Dihedral	10 deg.
Incidence (variable)	-10 to 1.0 deg.
Sweepback (25% chord line)	35 deg.
Aspect ratio	4.0
Taper ratio	0.329

C. Vertical Tail Surfaces

Span	25 ft. 11 in.
Aspect ratio	1.9
Taper ratio	0.299
Sweepback (25% chord line)	35 deg.

Areas:

Vertical tail (total, excluding dorsal fin but including area within fuselage)	351.7 sq. ft.
Rudder (including 34.4 square feet of balance area forward of hinge line and 8.1 square feet of tab area aft of tab hinge line)	128.8 sq. ft.

D. Fuselage

Height (maximum cross section)	13 ft. 7 in.
Width (maximum cross section)	12 ft. 3 in.
Overall length	157 ft. 5 in.

E. Landing Gear

Main

Tread	20 ft. 10 in.
Wheel base	60 ft. 10 in.
Tires	44 x 16 in.
Nose Tires	34 x 11 in.
Maximum Nosewheel steering angle	61 deg.
Width required for 180-degree turn	115 ft.

26. DC-8-63

A. Wing Group

Span:

Wing (overall)	148 ft. 5.0 in.
Ailerons (each side)	24 ft. 0 in.
Flaps (each side)	33 ft. 10 in.

Areas:

Wing (total, including ailerons, flaps, and area within the fuselage)	2926.8 sq. ft.
Ailerons (total, both sides, excluding balance area forward of hinge line but including 23 square feet of tab area aft of tab hinge line)	161.6 sq. ft.
Flaps (total)	456.9 sq. ft.
Dihedral (at trailing edge)	6.5 deg.
Sweepback (25% chord line)	30.6 deg.
Aspect ratio	7.52
MAC	795.8

Leading Edge (at fuselage) Station	272.8 in.
Taper ratio	0.197
Flap maximum deflection	50.0 deg.

B. Horizontal Tail Surfaces

Span	47 ft. 6 in.
Areas:	
Horizontal surfaces (total, including area within fuselage)	559.1 sq. ft.
Stabilizer (excluding elevator and overhanging elevator balance but including area within fuselage)	391.1 sq. ft.
Elevators (total, including 42.5 square feet of balance area forward of hinge line and including 20.9 square feet of total tab area aft of tab hinge line)	167.9 sq. ft.
Dihedral	10 deg.
Incidence (variable)	-10 to 1.0 deg.
Sweepback (25% chord line)	35 deg.
Aspect ratio	4.0
Taper ratio	0.329

C. Vertical Tail Surfaces

Span	25 ft. 11 in.
Aspect ratio	1.9
Taper ratio	0.299
Sweepback (25% chord line)	35 deg.
Areas:	
Vertical tail (total, excluding dorsal fin but including area within fuselage)	351.7 sq. ft.
Rudder (including 34.4 square feet of balance area forward of hinge line and 8.1 square feet of tab area aft of tab hinge line)	128.8 sq. ft.

D. Fuselage

Height (maximum cross section)	13 ft. 7 in.
Width (maximum cross section)	12 ft. 3 in.
Overall length	187 ft. 5 in.

E. Landing Gear

Main

Tread	20 ft. 10 in.
Wheel base	77 ft. 6 in.
Tires	44 x 16 in
Nose Tires	34 x 11 in
Maximum Nosewheel steering angle	67 deg.
Width required for 180-degree turn	132 ft.

27. Lifting

A. The main landing gear contains integral jack balls located on the lower side of the axle housings, midway between each set of wheels. A jack pad is used at the nose gear axle jack point. The maximum allowable jacking loads on the main and nose gear jack points are in excess of any anticipated loading.

(1) The entire airplane can be lifted at the nose and main gear axle points with the airplane at maximum ramp weight. Therefore, there are no load or weight restrictions when jacking at these points. Lifting the airplane in this manner is generally done for service of the tires, wheels, and brakes.

(2) When possible, the airplane should be moved to a level surface known to be capable of supporting each jack. The jacking site selected should be protected from the wind, preferably in a hangar. When lifting the airplane in unprotected open areas, the airplane should be headed into the wind, with wind velocity not to exceed 25 knots during period airplane is on jacks.

B. Three recessed jack points are provided on the primary structure for lifting the entire airplane. One is located aft of the nosewheel well on the fuselage center--line at station 271.5 and one is located on each wing at the junction of the outboard auxiliary spar and the rear spar, 69.2 inches outboard of the main gear strut centerline and 6.7 inches forward of the main gear strut centerline. The maximum static load limit on the fuselage nose jack point is 23,000 pounds and at each wing jack point 97,700 pounds.

(1) The entire airplane can be lifted at the wing and fuselage nose jack points. Lifting the airplane at these points is generally done to perform landing gear tests or to remove or install nose and main gear components.

(2) When possible, the airplane should be moved to a level surface known to be capable of supporting each jack. The jacking site selected should be protected from the wind, preferably in a hangar. When lifting the airplane in unprotected open areas, the airplane should be headed into the wind, with wind velocity not to exceed 25 knots during period airplane is on jacks.

(3) Before starting the lifting operation, the load limits for the wing and fuselage jack points must be known. A nomogram provides a rapid and convenient means of determining these limits based on gross weight and center of gravity for the airplane.

(4) The forward upper cargo door, if installed, must be closed and latched. No cargo is to be loaded or unloaded while airplane is on jacks.

C. Additional auxiliary support points are provided on each wing and at the tail skid/mooring fitting (61 & 63). The tail skid support may be used as a precautionary measure when the center of gravity of the airplane has moved aft through engine removal or similar circumstances. Capacity of the tail skid support is 2,500 pounds. The auxiliary support points on each wing may be used with special jacks to stabilize the airplane laterally. Any support equipment used at the wing points should be provided with a relief valve or mechanical fuse so that the vertical load does not exceed 13,500 pounds.

D. The entire airplane can be lifted by using a combination of wing, fuselage nose, main landing gear, and nose gear jack points. Lifting the airplane at a combination of jack points is generally done because of special maintenance to be accomplished or because jacks for regular lifting are not available.

E. Pneumatic lifting bags can assist in raising a damaged airplane which has belly landed or which has a collapsed landing gear. The pneumatic bags may also be used to lift the entire airplane when conventional jacking is not practical or standard jacks are not available. When the airplane is resting on a runway or equivalent hard ground surface, there is adequate clearance for pneumatic bag placement. If the airplane has plowed into soft ground, it will be necessary to undermine the airplane lifting areas to enable placement of pneumatic bags. Adequate mooring is mandatory to prevent the airplane from shifting due to instability of the bags.

28. Shoring

A. An airplane at rest on its landing gear or on jacks has definite stresses imposed on certain structural parts of the wing and fuselage. These stresses must be relieved by adequate shoring before any major repair or modification work can begin. An airplane supported by proper jacking and shoring methods can be repaired without causing built-in stress concentrations.

B. Shoring is used beneath the fuselage and wing depending upon the particular work to be performed. Major shoring locations are structural elements such as the fuselage frames, wing spars, jack pads, landing gear fittings, and wing fuel tank bulkheads. Care must be taken to avoid overloading any one shoring station. When the airplane is to be supported by any means other than the main gear, every effort must be made to include regular jacking locations among the points of support.

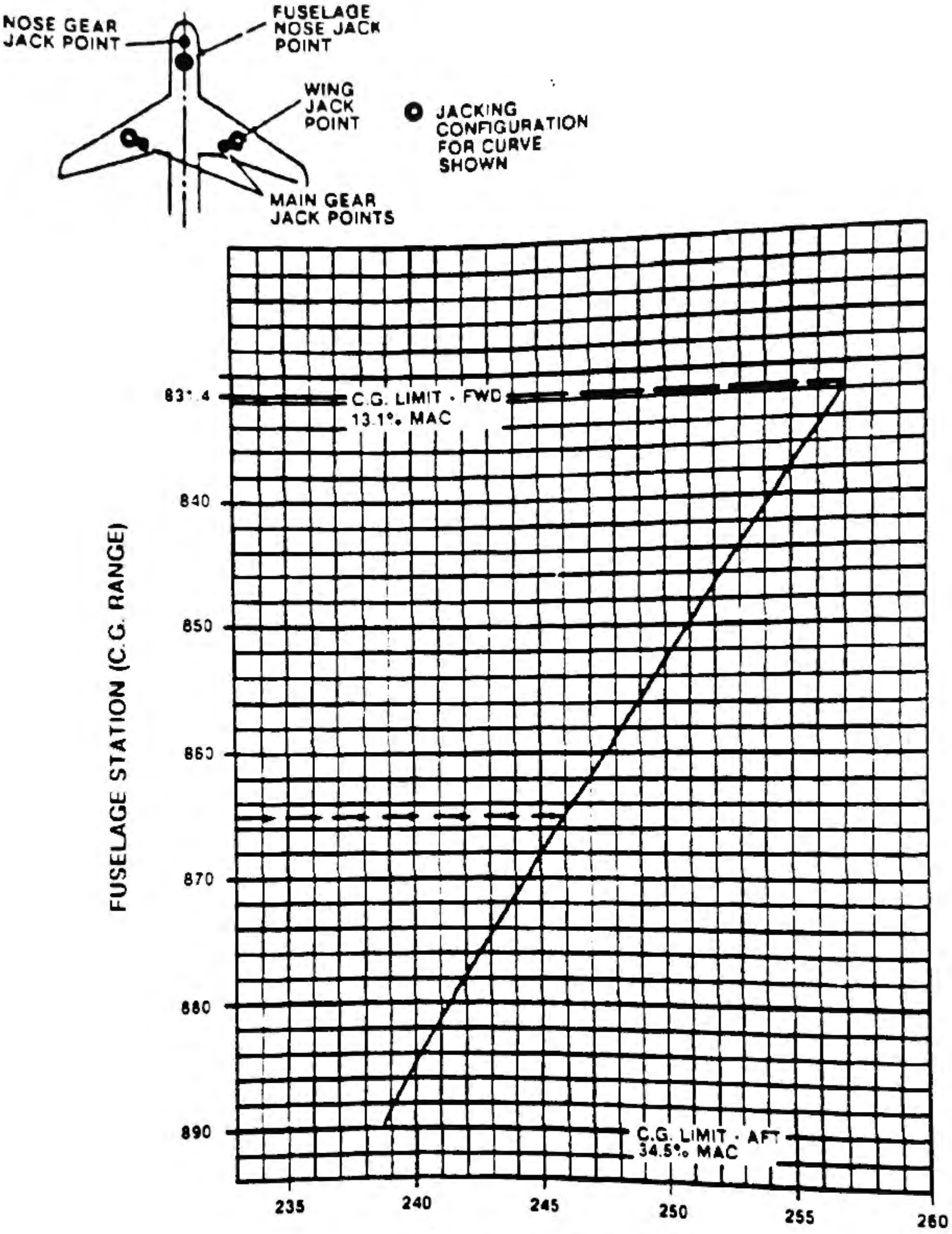
29. Wing and Fuselage Lifting - Maintenance Practices

A. General

(1) The entire airplane can be lifted at the wing and fuselage nose jack points. Lifting the airplane at these points is generally done to perform landing gear tests or to remove or install nose and main gear components.

(2) When possible, the airplane should be moved to a level surface known to be capable of supporting each jack. The jacking site selected should be protected from the wind, preferably in a hangar. When lifting the airplane in unprotected open areas, the airplane should be headed into the wind, with wind velocity not to exceed 25 knots during period airplane is on jacks.

(3) Before starting the lifting operation, the load limits for the wing and fuselage jack points must be known. A nomogram (see Figure 1-44) provides a rapid and convenient means of determining these limits based on gross weight and center of gravity for the airplane.



SAMPLE. IF CENTER OF GRAVITY IS AT STATION 865, MAXIMUM ALLOWABLE GROSS WEIGHT FOR JACKING AT THIS CONFIGURATION IS 246,100 LBS.

JACKING LIMITS - AIRPLANE ON WING AND FUSELAGE NOSE JACK POINTS

Figure 1-44

FTX80685

(4) When raising or lowering freighter airplanes, the forward upper cargo door must be closed and latched. No cargo is to be loaded aboard or unloaded from fuselage while airplane is on jacks.

B. Jacking Procedures

CAUTION: **WHEN RAISING OR LOWERING FREIGHTER AIRPLANES, THE FORWARD UPPER CARGO DOOR MUST BE CLOSED AND LATCHED. NO CARGO IS TO BE LOADED ABOARD OR UNLOADED FROM FUSELAGE WHILE AIRPLANE IS ON JACKS TO PREVENT POSSIBLE STRUCTURAL DAMAGE.**

(1) Jacking an airplane at wing and fuselage nose jack points.

(a) Make certain landing gear lockpins are installed.

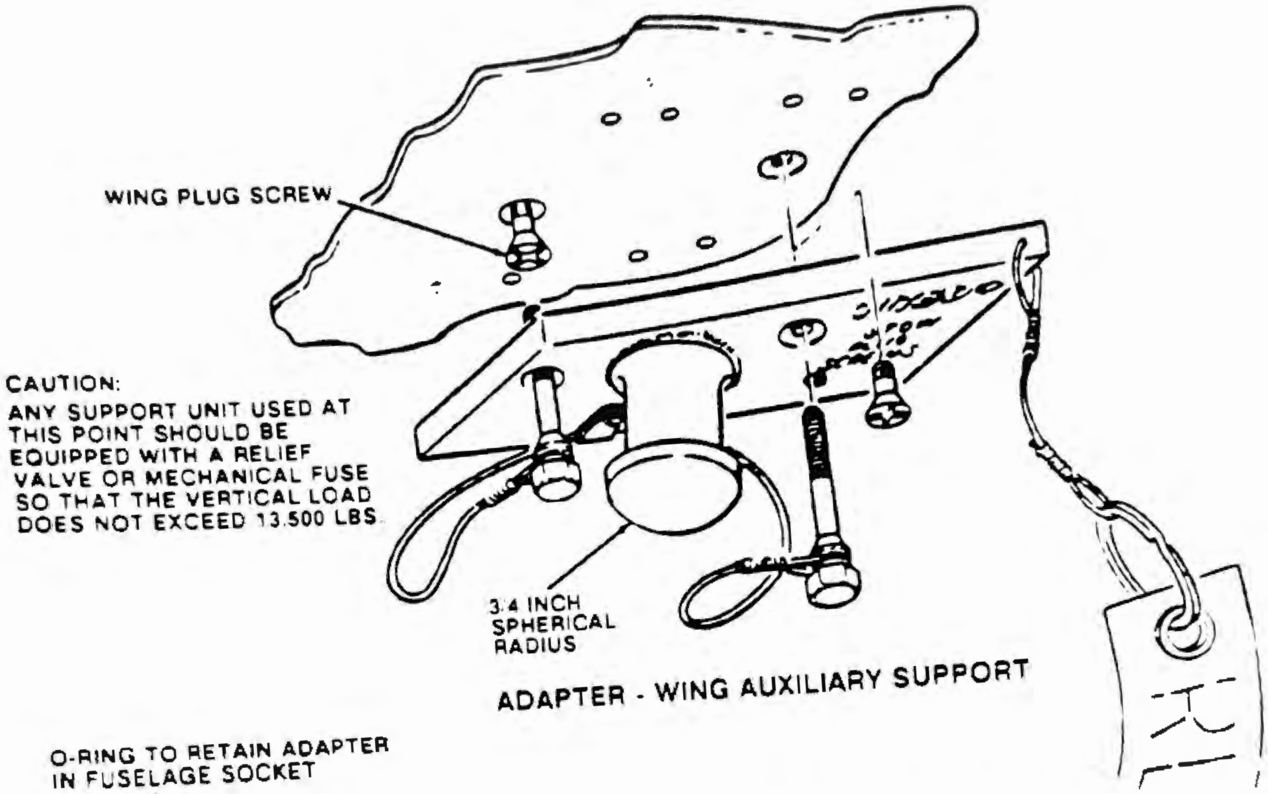
(b) Make certain airplane is electrically (static) grounded through ground cables connected to ground provision, located on inboard engine cowlings or on main landing gear, and to grounding facility on the apron or in the hangar.

(c) Use data given in Figure 1-44 to determine weight at fuselage and wing jack points based on gross weight and center of gravity for the airplane. Make certain maximum load limits are not exceeded.

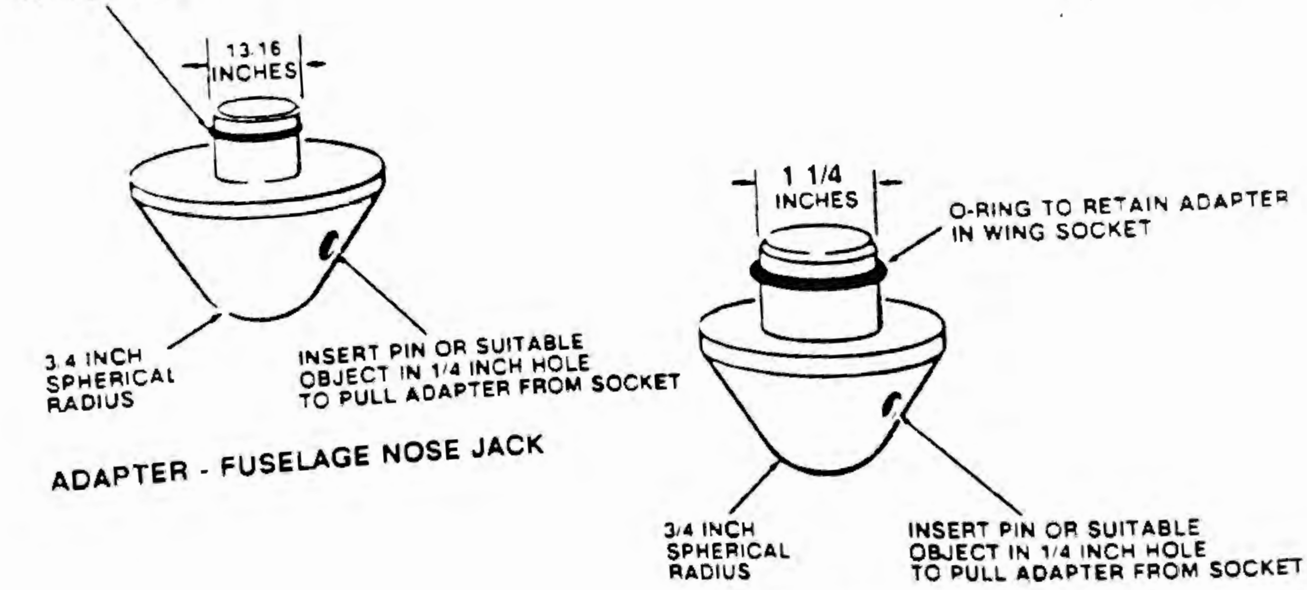
(d) Install fuselage nose jack adapter (see Figure 1-45) at fuselage nose jack point (see Figure 1-46).

(e) Position jack beneath each wing jack adapter and beneath fuselage nose adapter. Extend jacks until they are snug against adapters.

WARNING: **WHEN USING JACKSCREW EXTENSIONS, MAKE CERTAIN SCREW IS NOT EXTENDED BEYOND SAFE THREAD ENGAGEMENT (THREE TO FOUR THREADS MINIMUM) TO PREVENT JACK COLLAPSING, RESULTING IN INJURY TO PERSONNEL AND SERIOUS DAMAGE TO THE AIRPLANE.**


WING PLUG SCREW
CAUTION:
ANY SUPPORT UNIT USED AT THIS POINT SHOULD BE EQUIPPED WITH A RELIEF VALVE OR MECHANICAL FUSE SO THAT THE VERTICAL LOAD DOES NOT EXCEED 13,500 LBS.
3/4 INCH SPHERICAL RADIUS

ADAPTER - WING AUXILIARY SUPPORT


O-RING TO RETAIN ADAPTER IN FUSELAGE SOCKET
13/16 INCHES
3/4 INCH SPHERICAL RADIUS
INSERT PIN OR SUITABLE OBJECT IN 1/4 INCH HOLE TO PULL ADAPTER FROM SOCKET
1 1/4 INCHES
O-RING TO RETAIN ADAPTER IN WING SOCKET
3/4 INCH SPHERICAL RADIUS
INSERT PIN OR SUITABLE OBJECT IN 1/4 INCH HOLE TO PULL ADAPTER FROM SOCKET

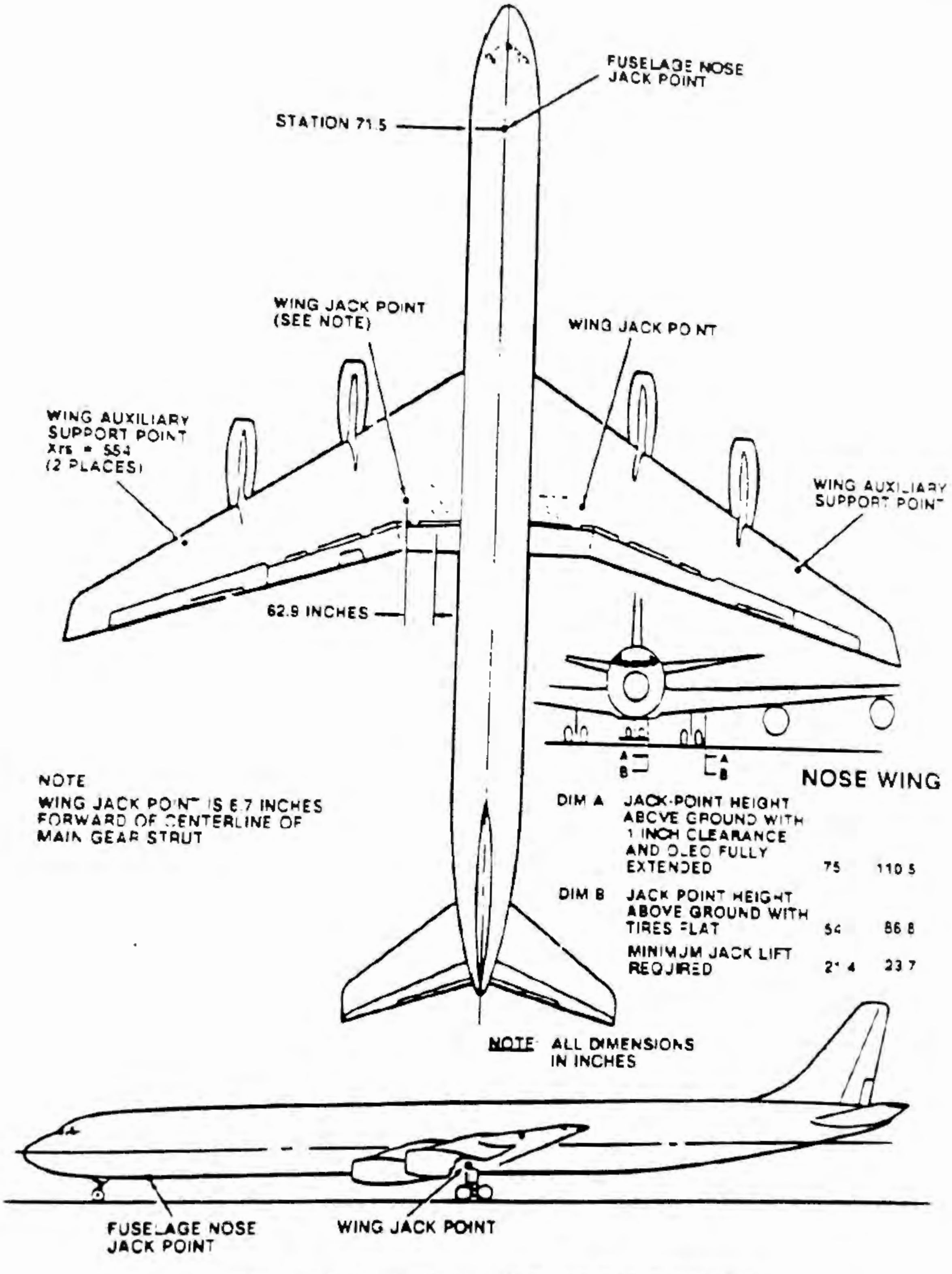
ADAPTER - FUSELAGE NOSE JACK

ADAPTER - WING JACK

WING AND FUSELAGE JACK ADAPTERS

FTX80686

Figure 1-45



NOTE
WING JACK POINT IS 6.7 INCHES FORWARD OF CENTERLINE OF MAIN GEAR STRUT

		NOSE	WING
DIM A	JACK-POINT HEIGHT ABOVE GROUND WITH 1 INCH CLEARANCE AND OLEO FULLY EXTENDED	75	110.5
DIM B	JACK POINT HEIGHT ABOVE GROUND WITH TIRES FLAT	54	86.8
	MINIMUM JACK LIFT REQUIRED	21.4	23.7

NOTE: ALL DIMENSIONS IN INCHES

WING AND FUSELAGE JACK POINTS

FTX80687

Figure 1-46

(f) Make certain jack cylinders are vertical at start of jacking operations to prevent side loads and possible gear strut binding.

(g) Extend jacks simultaneously until desired ground clearance is obtained. As jacks extend, maintain follower nut of each jack in close contact with jack base.

NOTE: **To maintain level attitude, use spirit levels on leveling brackets located in nosewheel well or in left main gear well . For exercising main gear, a minimum of 3 inches ground clearance is required for swing.**

(2) Lowering Instructions

WARNING: **MAKE CERTAIN LANDING GEAR DOWN LOCK PINS ARE INSTALLED TO PREVENT INADVERTENT MOVEMENT OF LANDING GEAR RESULTING IN INJURY TO PERSONNEL OR DAMAGE TO EQUI**

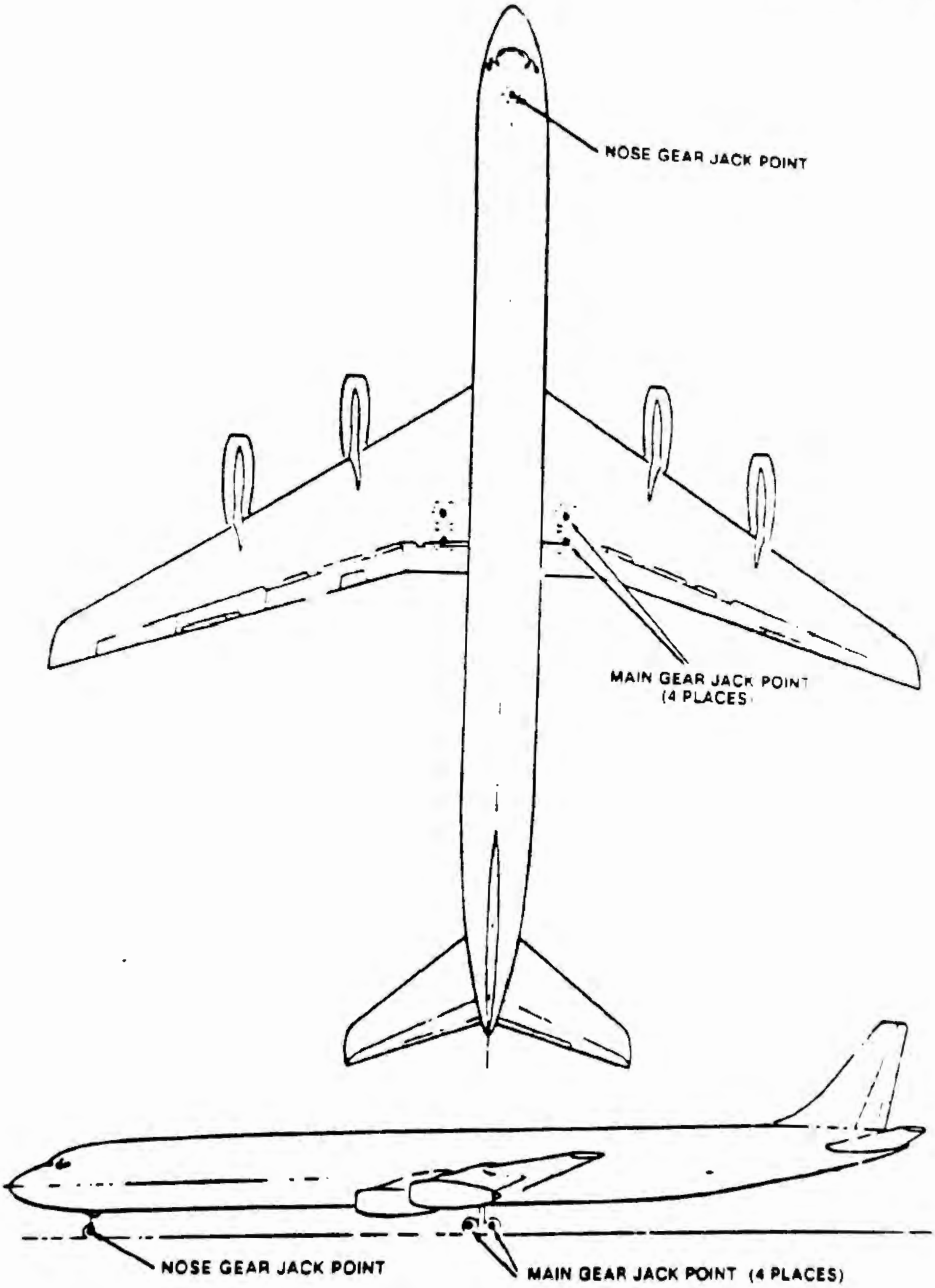
(a) On completion of maintenance, retract all jacks simultaneously until airplane weight is assumed by landing Relieve follower nuts only enough to stay ahead of jack retraction and never more than 1/2 inch from jack shoulder.

(b) Remove jack and place clear of airplane; remove and stow jack adapt

30. Nose and Main Gear Lifting - Maintenance Practices

A. General

(1) The entire airplane can be lifted at the nose and main gear axle jack points (see Figure 1-47) with the airplane at maximum ramp weight. Therefore, there are no load or weight restrictions when jacking at these points. Lifting the airplane in this manner is generally done for service of the tires, wheels, and brakes.


NOSE GEAR JACK POINT
MAIN GEAR JACK POINT (4 PLACES)
NOSE GEAR JACK POINT
MAIN GEAR JACK POINT (4 PLACES)

NOSE AND MAIN GEAR JACK POINTS

FTX80688

Figure 1-47

(2) When possible, the airplane should be moved to a level surface known to be capable of supporting each jack. The jacking site selected should be protected from the wind, preferably in a hanger. When lifting the airplane in unprotected open areas, the airplane should be headed into the wind, with wind velocity not to exceed 25 knots during period airplane is on jacks.

B. Jacking Procedures

(1) Jacking an airplane with normally inflated tires

(a) Make certain landing gear lockpins are installed.

(b) Make certain airplane is electrically (static) grounded through grounding cables connected to grounding provision, located on inboard engine cowlings or on main landing gear, and to a ground facility on apron or in hangar.

(c) Position jack under nose gear axle using nose gear jack pad or adapter (see Figure 1-48). Extend jack until pad or adapter is snug against axle.

(d) Position jack under each main gear axle. Extend jack until jack is snug against axle jack ball.

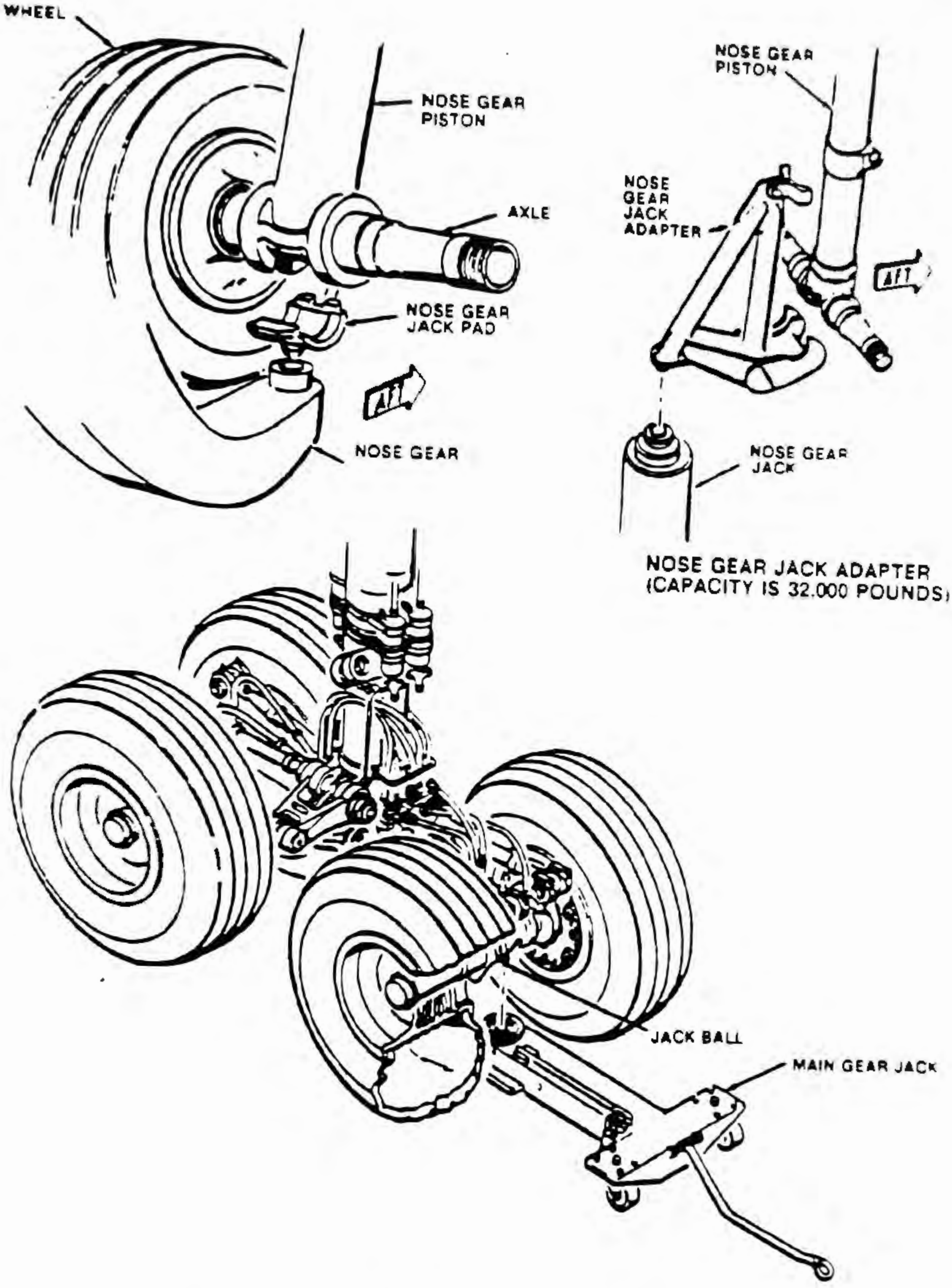
(e) Extend all jacks evenly until tires are clear of ground.

CAUTION: WHEN JACKING FORWARD AXLE OF BOGIE, OBSERVE FORWARD BRAKE COMPENSATING LINK; DAMAGE CAN OCCUR IF FORWARD AXLE IS JACKED TOO FAR ABOVE REAR AXLE.

NOTE: To maintain level attitude, use spirit levels on leveling brackets located in nosewheel well or in left main gear wheel well.

(2) Jacking an airplane with deflated tires

(a) Make certain landing gear lockpins are installed.



LANDING GEAR JACK ADAPTERS

FTX80689

Figure 1-48

(b) Make certain airplane is electronically (static) grounded through grounding cables connected to grounding provision, located on inboard engine cowlings or on main landing gear, and to grounding facility on apron or in hangar.

(c) To lift airplane with one or both nose gear tires flat using a cantilever type jack, position cantilever nose jack under nose gear axle with nose gear jack pad (see Figure 1-48).

(d) To lift airplane with one or both nose gear tires flat using conventional jack, position jack adapter between jack and nose gear axle with collar of adapter resting against nose gear strut cylinder (see Figure 1-49).

(e) To lift airplane with one or more main gear tires flat, position cantilever jack between each pair of main gear wheels (see Figure 1-50). Extend jack until jack is snug against axle ball.

NOTE: With rear and front tires flat on one bogie, change rear tires first.

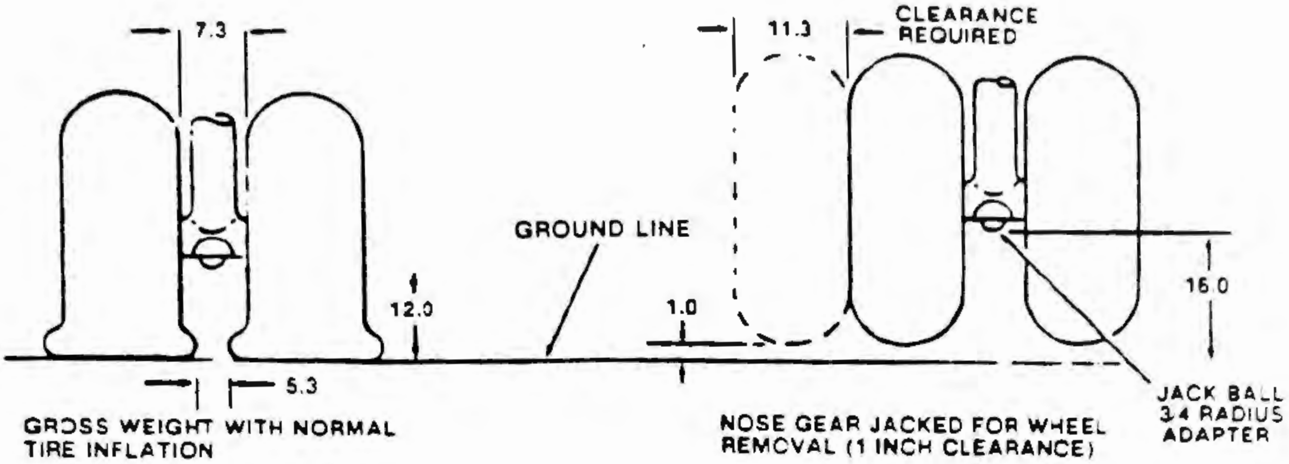
(f) Extend jacks evenly until tires are clear of ground.

CAUTION: WHEN JACKING FORWARD AXLE OF BOGIE, OBSERVE FORWARD BRAKE COMPENSATING LINK; DAMAGE CAN OCCUR IF FORWARD AXLE IS JACKED TOO FAR ABOVE REAR AXLE.

NOTE: If level attitude is desired, use spirit levels on leveling brackets located on nosewheel well or in left main gear wheel well.

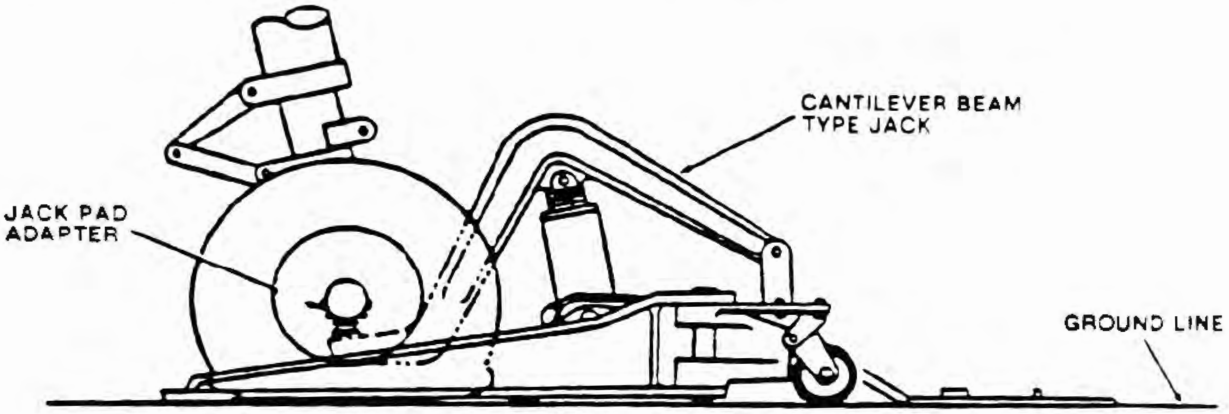
(3) Lowering Instructions

WARNING: MAKE CERTAIN LANDING GEAR DOWNLOCK PINS ARE INSTALLED TO PREVENT INADVERTENT MOVEMENT OF LANDING GEAR, RESULTING IN INJURY TO PERSONNEL OR DAMAGE TO EQUIPMENT.

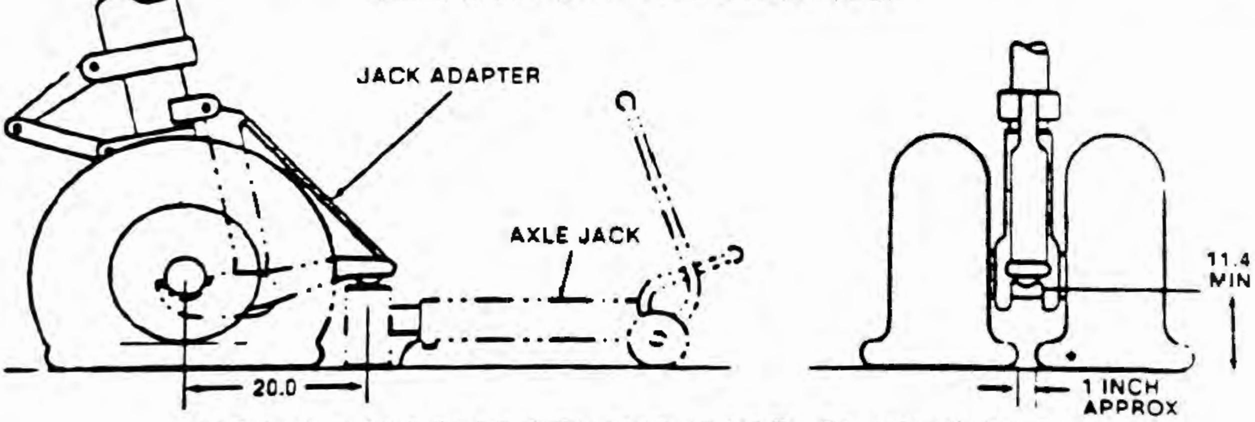


GROSS WEIGHT WITH NORMAL TIRE INFLATION

NOSE GEAR JACKED FOR WHEEL REMOVAL (1 INCH CLEARANCE)



NOSE GEAR WITH CANTILEVER JACK



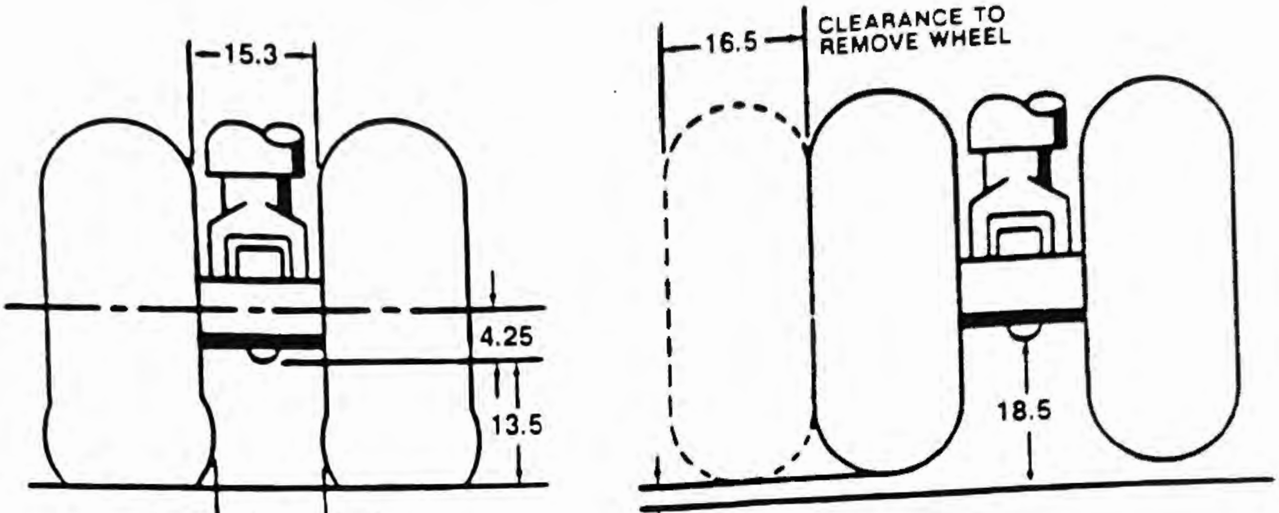
JACKING NOSE GEAR WITH TWO FLAT TIRES, USING AXLE JACK AND JACK ADAPTER, DOUGLAS NUMBER 5706789

NOTE: DIMENSIONS ARE GIVEN TO THE NEAREST TENTH OF INCH. * THIS THIS DIMENSION IS VARIABLE WHEN TIRES ARE UNDER INFLATED OR FLAT.

NOSE GEAR JACKING INFORMATION

FTX80690

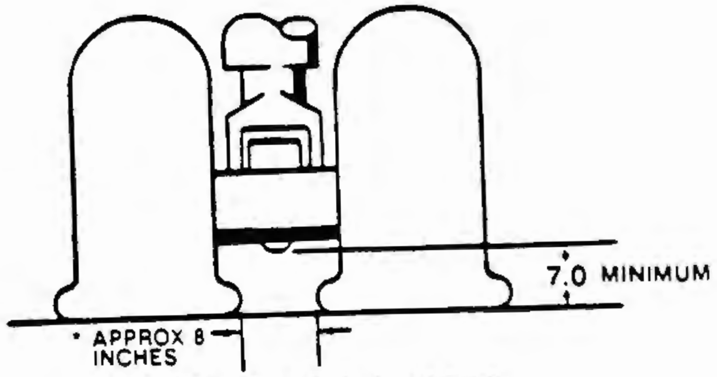
Figure 1-49



GROSS WEIGHT WITH NORMAL TIRE INFLATION

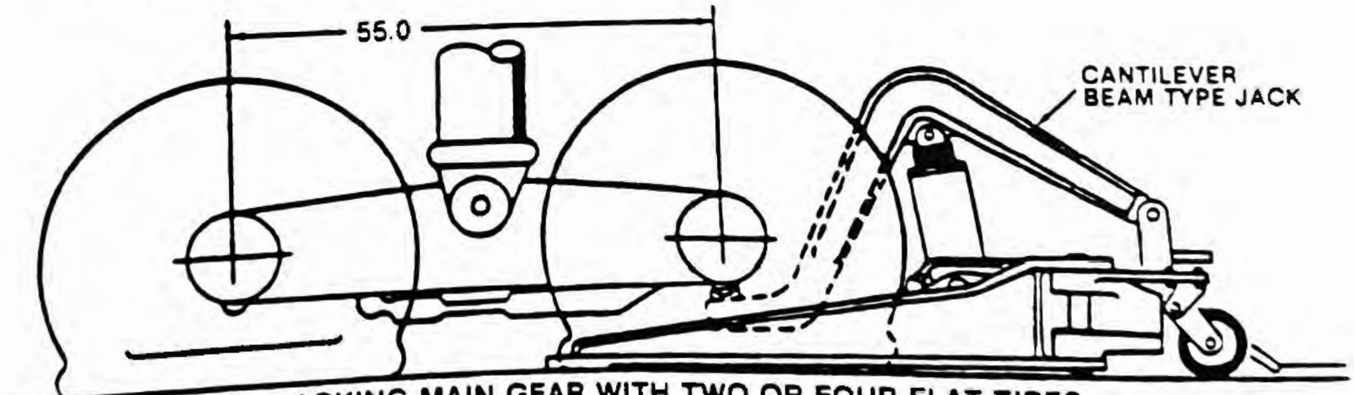
MAIN GEAR JACKED FOR WHEEL REMOVAL (1 INCH CLEARANCE)

NOTE: DIMENSIONS ARE GIVEN TO THE NEAREST TENTH OF AN INCH



* THIS DIMENSION IS VARIABLE WHEN TIRES ARE UNDER INFLATED OR FLAT

TWO ADJACENT FLAT TIRES



JACKING MAIN GEAR WITH TWO OR FOUR FLAT TIRES

MAIN GEAR JACKING INFORMATION

FTX80691

Figure 1-50

(a) On completion of maintenance, retract all jacks simultaneously until airplane weight is assumed by landing gear. Relieve follower nuts only enough to stay ahead of jack retraction and never more than 1/2 inch from jack shoulder.

(b) Remove jacks and place clear of airplane; remove and stow jack adapter.

C. Stabilizing the Airplane

(1) Stabilizing the airplane using auxiliary wing supports

(a) Install wing auxiliary support adapter (see Figure 1-45) at wing auxiliary support point (see Figure 1-46).

(b) Position wing stabilizing jack beneath adapter, and extend jack until jack is snug against adapter.

CAUTION: JACK MUST BE SET TO RELIEVE AT 13,500 POUNDS TO ENSURE AGAINST STRUCTURAL DAMAGE TO THE WING.

(c) On completion of maintenance, lower, remove, and place jack clear of airplane.

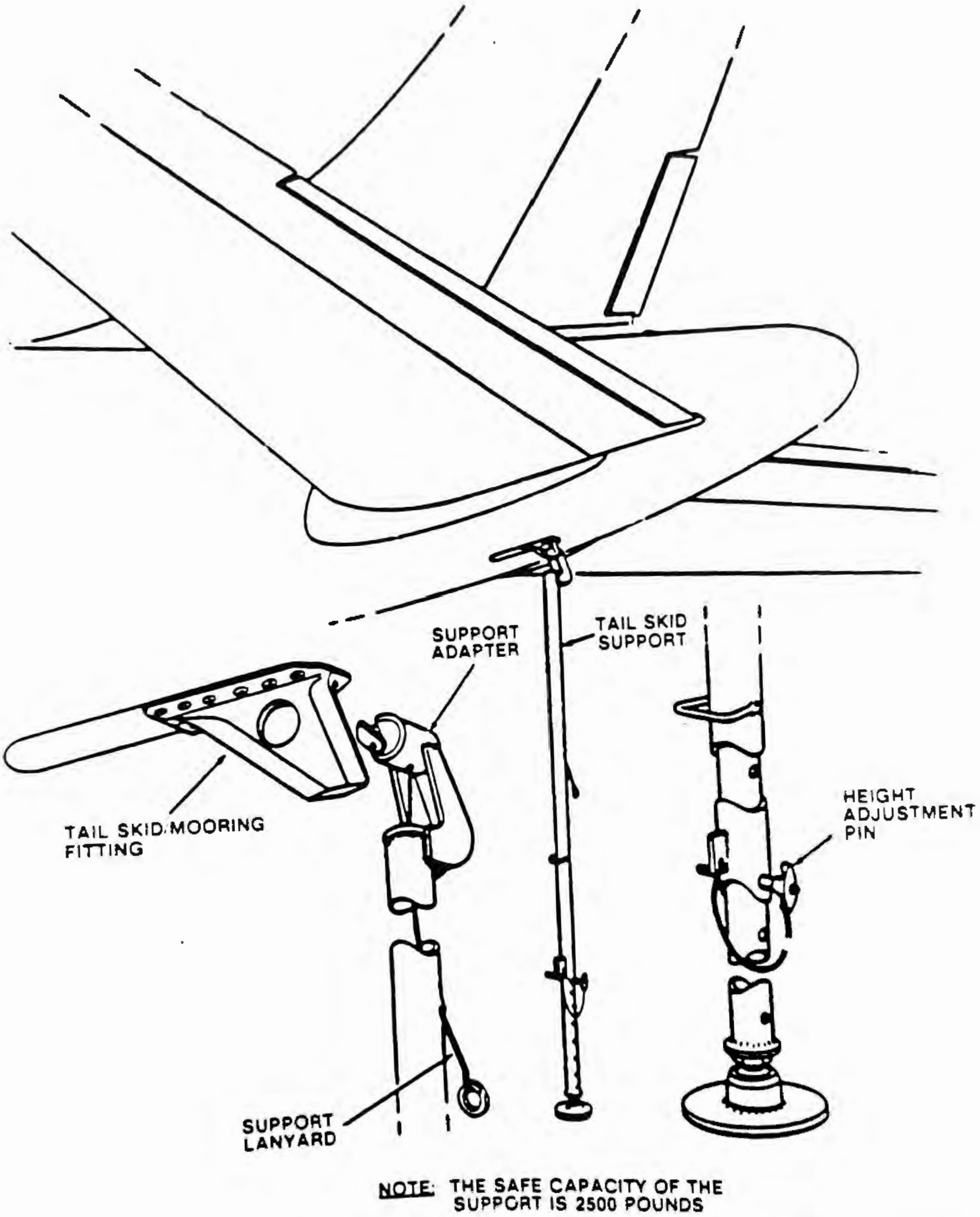
(d) Remove and stow wing auxiliary support adapter.

(2) Stabilizing the airplane using tail skid support

(a) Place tail skid support in position (see Figure 1-51).

(b) Pull down on support lanyard ring to collapse support adapter lockarm.

(c) Insert support adapter into hole in tail skid, and then release lanyard to lock support in tail skid.



NOTE: THE SAFE CAPACITY OF THE SUPPORT IS 2500 POUNDS

TAIL SKID/MOORING FITTING SUPPORT

FTX80692

Figure 1-51

(d) Remove and install pin located in lower half of support to adjust height of support.

NOTE: Maximum safe capacity of tail skid support is 2500 pounds.

(e) On completion of maintenance, and after all weight has been removed from support, pull down on support lanyard ring to collapse support adapter lockarm and remove support from tail skid.

31. General

A. The airplane must be operated within definite weight and balance limits. Therefore, it is essential that weights and center-of-gravity be accurately determined. The empty weight and center-of-gravity are determined from information obtained by leveling and weighing.

B. The airplane must be level during weighing operations.

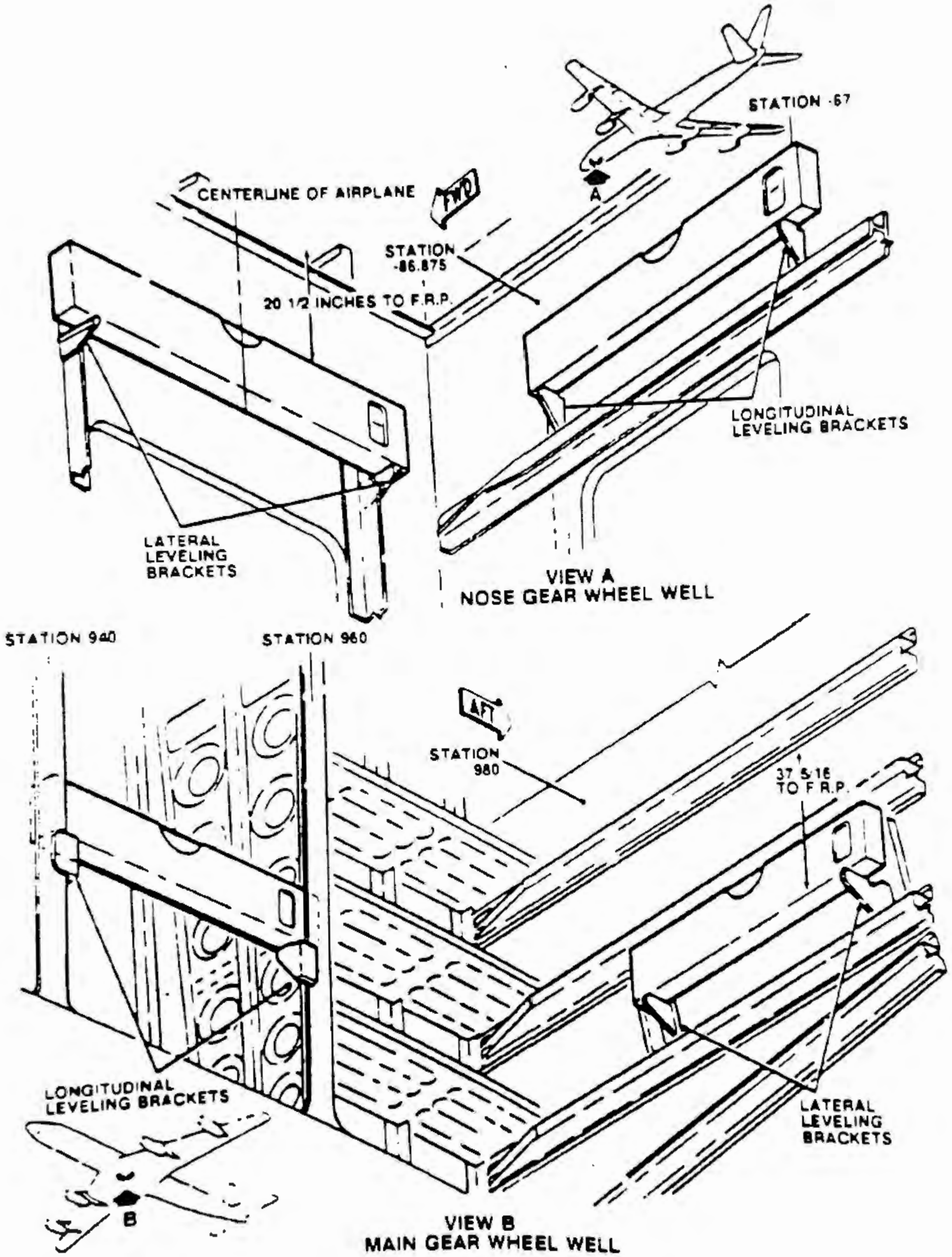
32. Leveling (See Figure 1-52)

A. The airplane may be leveled by jacking either at the main gear jack points and the nose gear jack point or at the wing jack points and the fuselage nose jack point.

B. Brackets for leveling the airplane are located in the nosewheel well approximately at fuselage station 101 and in the left main gear wheel well approximately at fuselage station 980. These brackets are used in conjunction with a spirit level.

C. Four transit leveling reference points are located just below the fuselage reference plane at stations 440 and 460 forward and at stations 1140 and 1160 aft.

D. As an external reference point for the determination of the horizontal arms of the weighing points, a plumb bob can be suspended from the centerline of the lower fuselage at the junction of the nose and center fuselage assemblies (fuselage station 70). There is also a jig-drilled hole on the lower centerline at station 926 from which a plumb line can be suspended.



LEVELING BRACKET LOCATIONS

FTX80693

Figure 1-52

33. Weighing

A. The recommended method of weighing the airplane is to use electronic load cells mounted on suitable jacks at the nose gear axle and main gear jacking points. An alternate method is to use the electronic load cells mounted on suitable jacks at the fuselage nose and wing jack points.

B. Weighing the airplane at the axle jack points is recommended from a safety standpoint. There is less possibility of damaging the airplane if a load cell should slip during jacking operations. Also, the lift required for ground clearance is much less at the axle jack points.

C. Cantilever-type jacks are not suitable for use with a weighing cell because of the side load imposed on the cell.

34. Description

A. Towing and taxiing procedures are basically the same as for other airplanes equipped with tricycle landing gear. The requirements differ, however, because of the higher weights involved.

B. The airplane can be towed forward or pushed backwards on hard surfaces, using a yoke-type towbar attached to the nosewheel.

(1) On airplanes equipped with a nosewheel steering bypass valve, placing the bypass valve in the bypass (open) position frees the nosewheel from the steering cylinders and allows steering control through the towbar; also, disconnecting the nosegear torque links to free the nosegear from the steering cylinders allows steering control through the towbar.

(2) On airplanes not equipped with the nosewheel steering bypass valve, steering control through the towbar may be accomplished by disconnecting the nosegear torque links to free the nosegear from the steering cylinders. Disconnecting the torque links will also affect the turning radius and runway width required for a 180-degree turn.

(3) On DC-8-61 airplane only, turning the nosewheel beyond 40-degrees unlocks the main gear swivel bogie on the inside of the turn and permits the rear wheels of the main gear to pivot outward. Unlocking the main gear bogie will affect the turning radius and runway width required for a 180-degree turn.

C. Hazard areas created by engine exhaust velocities and high temperatures during run-up should be cleared of personnel prior to engine start.

D. At times an airplane with one or more flat tires must be moved from an active runway or taxiway. Prior to movement of an airplane in a multiple flat tire condition, numerous variables that might cause more damage should be considered. In addition to the flat tire situation, the variables to be considered include weather, ramp inclination, airplane weight, asymmetrical loading, center of gravity location, tire tread, position and condition of landing gear components, etc. Because of these numerous possibilities, (See Figure 1-53) does not list all possible conditions which may require consideration before moving an airplane, but can be a useful guide for determining allowable taxiing or towing with one or more flat tires.

WARNING: ALLOW SUFFICIENT TIME FOR TIRES AND LANDING GEAR COMPONENTS TO COOL BEFORE ALLOWING PERSONNEL TO PERFORM ANY MAINTENANCE.

DURING TAXI OR TOWING OPERATION, KEEP PERSONNEL CLEAR OF LANDING GEAR AREA.

CAUTION: RAISE FLAPS AND CLOSE LANDING GEAR DOORS TO PRECLUDE ANY DAMAGE OR FURTHER DAMAGE.

MAIN GEAR	TIRE FOOTPRINT EXAMPLES	TAXIING ALLOWED	TOWING ALLOWED	DISTANCE ALLOWED TAXIING & TOWING	NOSE WHEEL ANGLE OF TURN	CONDITION OF RUNWAY	SPECIAL REQUIREMENTS
CONDITION (1) ONLY ONE FLAT TIRE (ANY TIRE	▮▯ ▯▯ ▯▯ OR ▯▯	YES	YES	UNLIMITED	NORMAL	SMOOTH	AVOID SHARP TURNS SUDDEN STARTS OR STOPS DURING AIRCRAFT MOVEMENT
CONDITION (2) ONE (1) FLAT TIRE PER AXLE IN TANDEM	▮▯ ▯▮ ▮▯ OR ▯▮	YES	YES BOTH MAIN GEARS ONLY	MINIMUM TO CLEAR RUNWAY	10 DEGREES MAXIMUM	SMOOTH	IF ADDITIONAL TIRE(S) FAIL AIRCRAFT SHOULD BE STOPPED AND SERVICEABLE WHEEL TIRE ASSEMBLY(IES) INSTALLED IN STAGGERED POSITIONS TO MINIMIZE GEAR DAMAGE MAXIMUM TAXIING OR TOWING SPEED IS LIMITED TO 5 M P H
CONDITION (3) ONE (1) FLAT TIRE PER AXLE STAGGERED	▮▯ ▯▮ ▯▮ OR ▮▯	YES	YES BOTH MAIN GEARS ONLY	TO TERMINAL HANGAR	10 DEGREES MAXIMUM	SMOOTH	ALL SPECIAL REQUIREMENTS LISTED ABOVE APPLY
CONDITION (4) TWO (2) FLAT TIRES ONE AXLE ONE SIDE	▮▮ ▯▯ ▯▯ OR ▮▮	YES	YES BOTH MAIN GEARS ONLY	MINIMUM TO CLEAR RUNWAY	10 DEGREES MAXIMUM	SMOOTH	1 SEE NOTE 2 BELOW 2 IN THIS CONDITION (TWO FLAT TIRES ON AXLE) AIRCRAFT MOVEMENT WILL ALLOW WHEEL FLANGES TO CONTACT RUNWAY SURFACES RESULTING IN ADDITIONAL WHEEL DAMAGE 3. ALL SPECIAL REQUIREMENTS LISTED ABOVE APPLY
CONDITION (5) THREE (3) FLAT TIRES ONE AXLE	▮▯ ▮▮ ▮▮ OR ▮▯	YES	YES BOTH MAIN GEARS ONLY	MINIMUM TO CLEAR RUNWAY	10 DEGREES MAXIMUM	SMOOTH	ALL SPECIAL REQUIREMENTS LISTED ABOVE APPLY SEE NOTE 2 BELOW
CONDITION (6) THREE (4) FLAT TIRES ONE SIDE	▮▮ ▮▮ ▮▮ OR ▮▮	YES	YES BOTH MAIN GEARS ONLY	MINIMUM TO CLEAR RUNWAY	10 DEGREES MAXIMUM	SMOOTH	ALL SPECIAL REQUIREMENTS LISTED ABOVE APPLY SEE NOTE 2 BELOW
NOSE GEAR							NOTE 1. NO SPECIAL INSPECTIONS ARE REQUIRED UNDER CONDITIONS (1), (2) OR (3) ABOVE 2 AN INSPECITON OF MAIN LANDING GEAR COMPONENTS IS REQUIRED UNDER CONDITIONS (4) (5) & 6
CONDITION I ONE (1) TIRE FLAT	▮▯	YES	YES BOTH MAIN GEARS ONLY	TO TERMINAL HANGAR	AVOID SHARP TURNS	SMOOTH	IF REMAINING TIRE FAILS AIRCRAFT SHOULD BE STOPPED AFTER CLEARING RUNWAY AND SERVICEABLE WHEEL TIRE ASSEMBLY(IES) INSTALLED PRIOR TO FURTHER AIRCRAFT MOVEMENT
CONDITION I TWO (2) TIRES FLAT	▮▮	YES	YES BOTH MAIN GEARS ONLY	MINIMUM TO CLEAR RUNWAY	10 DEGREES MAXIMUM	SMOOTH	AFTER CLEARING RUNWAY INSTALL SERVICEABLE WHEEL TIRE ASSEMBLY(IES) PRIOR TO FURTHER AIRCRAFT MOVEMENT

WHEN CONDITIONS OR COMBINATION OF CONDITIONS NOTED IN "TIRE FOOTPRINT" COLUMN OCCUR SIMULTANEOUSLY ON RIGHT AND LEFT MLG THE MOST CRITICAL CONDITION GOVERNS OPERATING LIMITATIONS

▯ INFLATED TIRE

▮ FLAT TIRE

CAUTION

THIS INFORMATION IS INTENDED AS A GUIDE FOR ABNORMAL TAXIING AND/OR TOWING DC-8 AIRCRAFT WITH FLAT TIRE(S). IT DOES NOT ATTEMPT TO LIST ALL POSSIBLE COMBINATIONS OF FAILED TIRES OR ADDITIONAL FACTORS WHICH MIGHT BE CONSIDERATIONS FOR SPECIFIC TOWING OPRATIONS. THIS INFORMATION DOES NOT SUPERSEDE ANY RESTRICTIONS AND/OR PROCEDURES CONTAINED IN EXISTING DOUGLAS PREPARED DC-8 MANUALS

CAUTION

AFTER ANY TIRE FAILURE THE AFFECTED WHEEL ASSEMBLY MUST BE INSPECTED PER THE APPLICABLE BENDIX OVERHAUL MANUAL PRIOR TO FURTHER USE

ABRUPT STARTS OR STOPS DURING TOWING, ROUGH OR SOFT RUNWAYS, OR SHARP TURNS WILL ALLOW WHEEL FLANGES TO CONTACT RUNWAY SURFACES AND MAY RESULT IN EXCESSIVE DAMAGE TO BOGIE BEAMS, TORQUE ARMS, WHEEL BRAKE ASSEMBLIES AND OTHER LANDING GEAR COMPONENTS.

TOWING OR TAXIING WITH FLAT TIRES

FTX80694

Figure 1-53

35. Towing - Description and Operation

A. Towing the airplane forward or pushing it aft is normally accomplished by using a tow vehicle and a yoke-type towbar attached with pins inserted in the ends of the nosewheel axle.

B. The nose gear towing load, directly forward or directly aft with the towbar parallel to the ground, is limited to 49,200 pounds. The maximum load limit in any turn is 24,600 pounds. The tow vehicle should be equipped with a torque converter to minimize acceleration and deceleration loads on the nose gear.

C. During the towing operation, the vehicle operator must make certain that turning limits of the nose gear are not exceeded. During noswheel towing, all turning is accomplished through the towbar. The nosewheel steering control is made inoperative by placing the steering bypass valve in the bypass (open) position and installing the steering bypass valve lockpin. On airplanes without bypass valve, nosewheel steering control is made inoperative by disconnecting nose gear torque links.

D. If the airplane is off the runway in soft sand, snow, or mud, towing can be accomplished at the main gear. This method of towing is used when conditions would exceed the towing load limits of the nose gear. Cables are attached to the main gear using a cable adapter assembly. When cables are used for towing, it is a good practice to attach connecting ropes at frequent intervals to minimize whipping in the event of a cable break. Maximum main gear towing load limit, within 30 degrees of directly forward is 81,000 pounds on each gear. Within 30 degrees of directly aft, maximum main gear towing load limit is 106,000 pounds on each gear. Steering during main gear towing is maintained through the nosewheel steering control, when hydraulic power is available. When the nose gear steering system cannot be used, steering is accomplished by using a third tow vehicle connected to the nose gear with a tow bar.

E. A qualified person must be stationed in the flight department during all phases of towing to watch for hazardous conditions and to stop the airplane using the airplane brakes in the event the towbar breaks or becomes uncoupled. Wing walkers should be stationed at strategic locations to aid in maneuvering the airplane through congested areas.

F. It is desirable to establish some form of communication between the tow vehicle operator and the person in the flight compartment either two-way radio (walkie-talkie) or through the airplane interphone system. Electrical power for airplane lights, radio communications with the control tower, hydraulic power, and interphone communication may be furnished by the tow vehicle.

36. Towing - Maintenance and Practices

A. General

(1) Towing the airplane over hard surfaces is accomplished at the nose gear for normal maintenance and ramp functions.

(2) Towing at the main gear is performed when the airplane is in soft sand, mud, or snow, or at any time it is determined that towing at the nose gear would exceed the nose gear towing load limit of 49,200 pounds.

(3) The approximate force required to start the airplane moving and to accelerate to a constant speed under various conditions, is given in Figure 1-54.

(4) Unlocking the main gear bogie (DC-8-61 airplanes only), opening the nosewheel steering bypass valve, and disconnecting the nosegear torque links affect the turning radii of the airplane. The limitations, turning angle restrictions, runway width and clearance requirements for a 180-degree turn are given in Figures 1-55, 1-56 and 1-57.

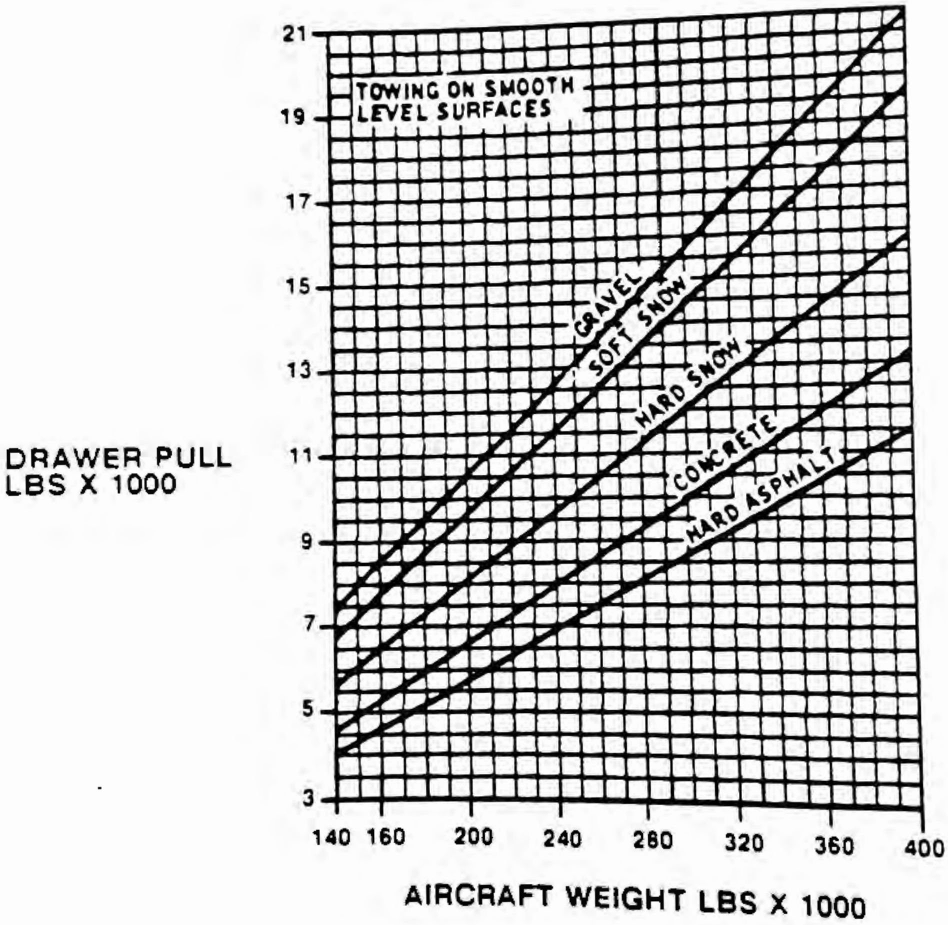
B. Nose Gear/Main Gear Towing (See Figures 1-58 and 1-59)

(1) Nose Gear Towing

(a) Make certain landing gear ground lockpins are installed.

(b) Make certain landing gear control lever is in down position.

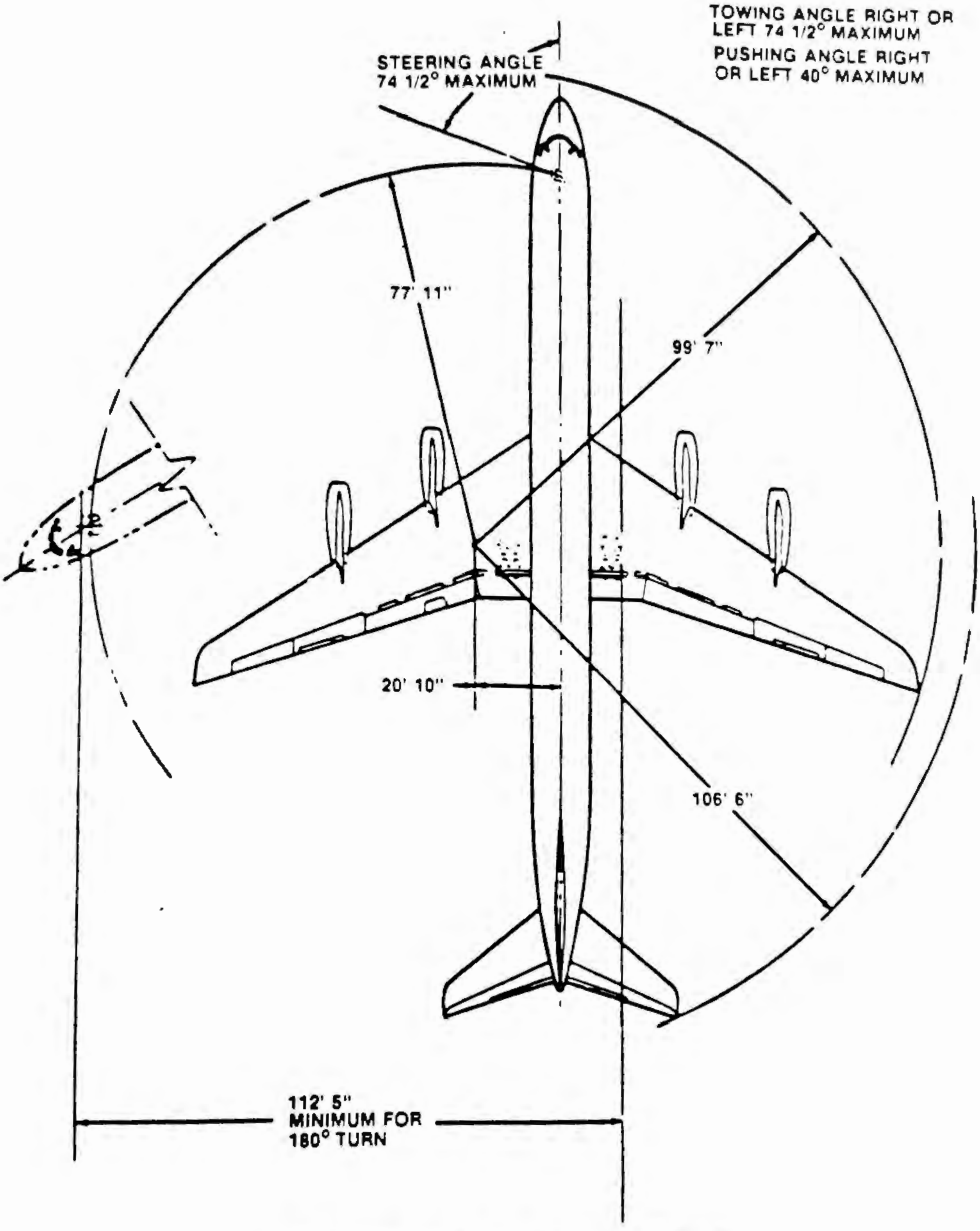
NOTE:
CHART SHOWS THE APPROXIMATE FORCE REQUIRED TO START AIRCRAFT AND ACCELERATE AT 30 FEET PER MINUTE PER SECOND TO A CONSTANT SPEED. FOR MAINTAINING A CONSTANT SPEED REDUCE THIS FORCE BY .015 X AIRCRAFT WEIGHT. FOR TOWING UP A GRADE ADD .010 X AIRCRAFT WEIGHT X PERCENT GRADE TO INDICATED APPROXIMATE FORCE OBTAINED FROM THE TABLE. (PERCENT GRADE EQUALS FEET OF RISE PER 100 FEET).



TOWING REQUIREMENTS

FTX80695

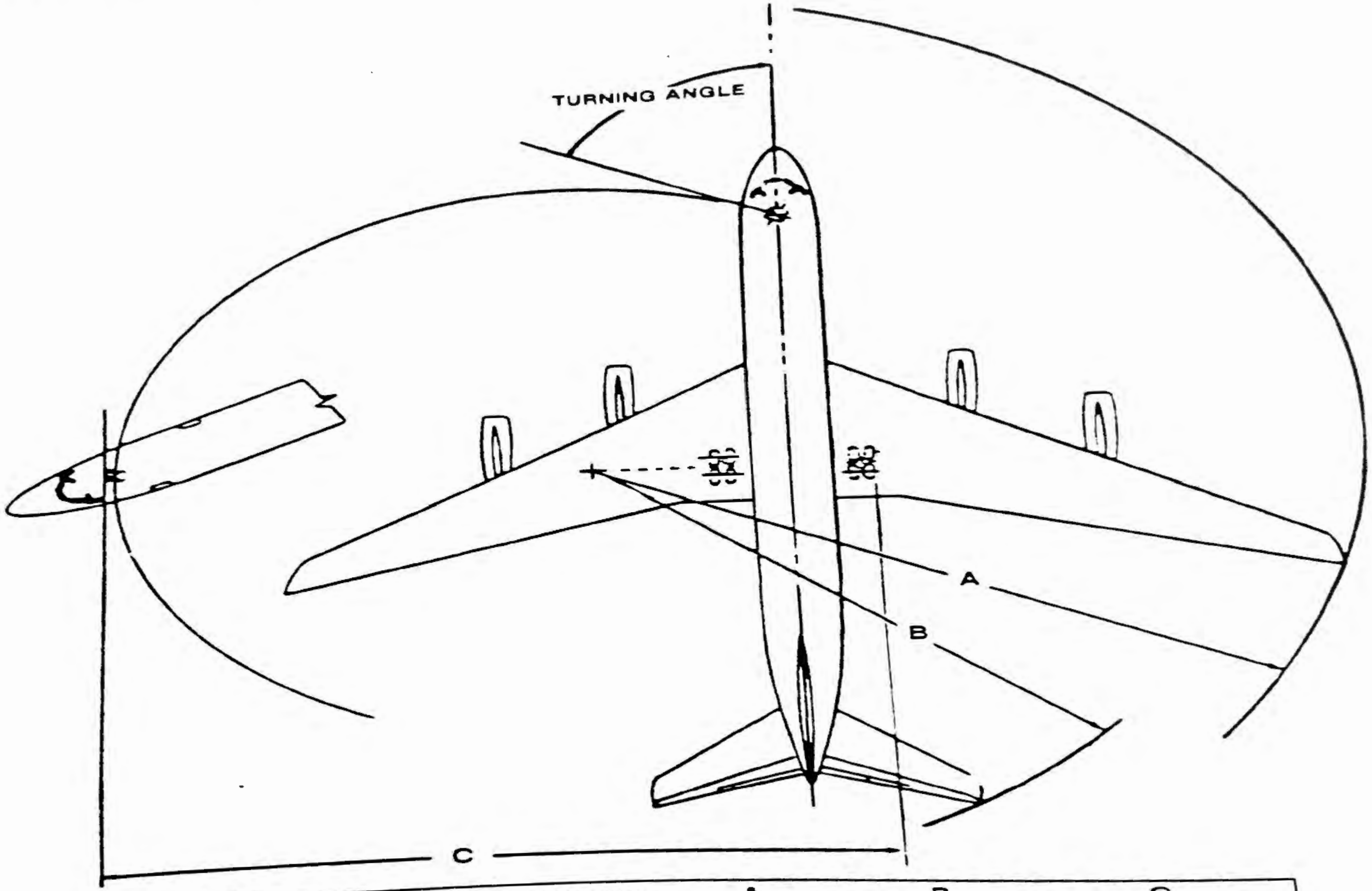
Figure 1-54


TOWING ANGLE RIGHT OR LEFT 74 1/2° MAXIMUM
PUSHING ANGLE RIGHT OR LEFT 40° MAXIMUM
STEERING ANGLE 74 1/2° MAXIMUM
77' 11"
99' 7"
20' 10"
106' 6"
112' 5" MINIMUM FOR 180° TURN

TURNING RADII DC-8 MODEL 61

FTX80696

Figure 1-55

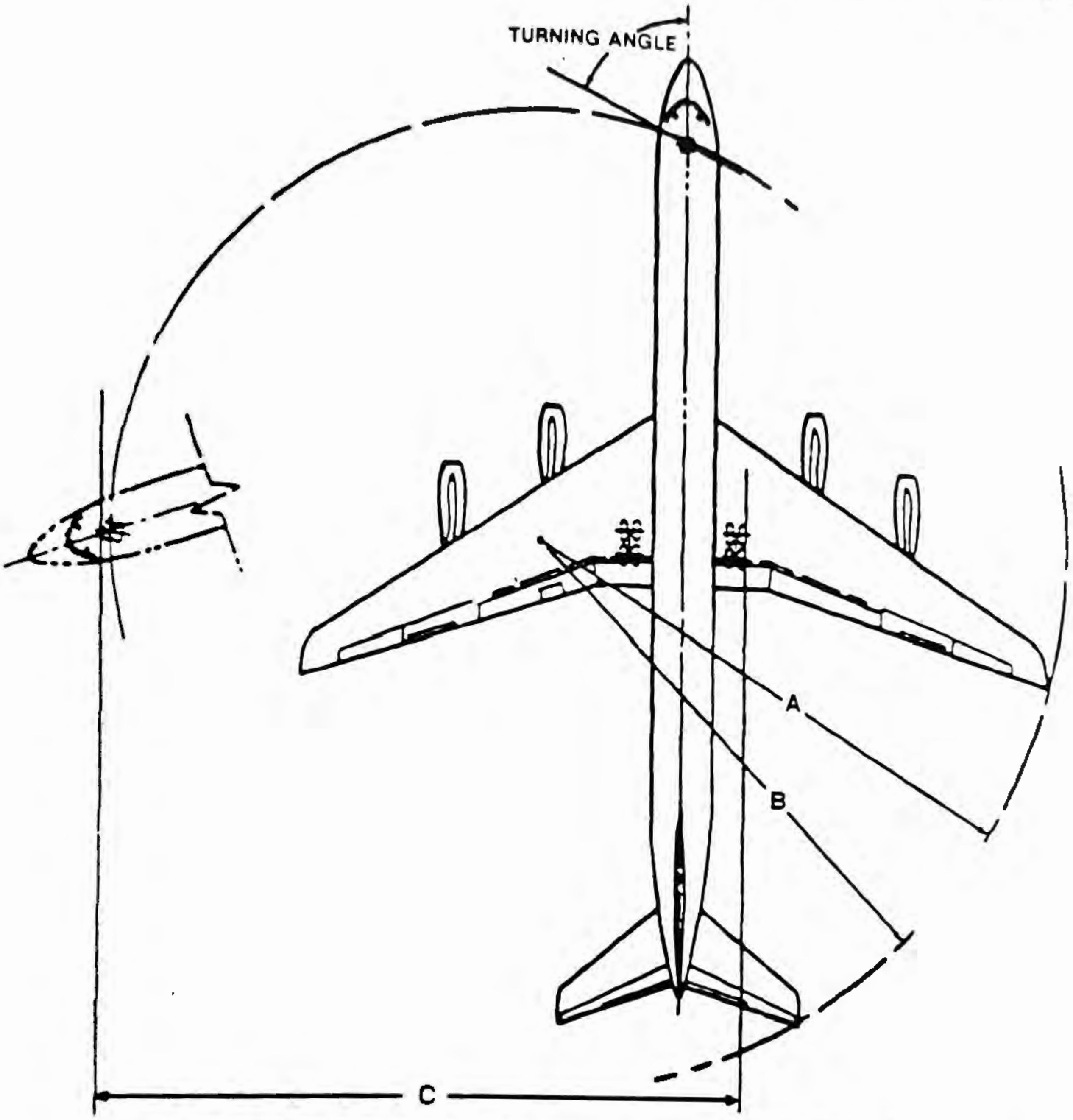


TURNING RADII CONDITIONS	MAXIMUM TURNING ANGLE	A WING TIP CLEARANCE	B HOR STAB CLEARANCE	C RUNWAY WIDTH FOR 180° TURN
TOWING OR PUSHING BYPASS VALVE OPEN, TORQUE LINKS CONNECTED	51°	130' 0"	115' 0"	141' 0"
TOWING OR PUSHING TORQUE LINKS DISCONNECTED	61°	111' 7"	98' 10"	115' 0"

TURNING RADII DC-8 MODEL 62

FTX80697

Figure 1-56

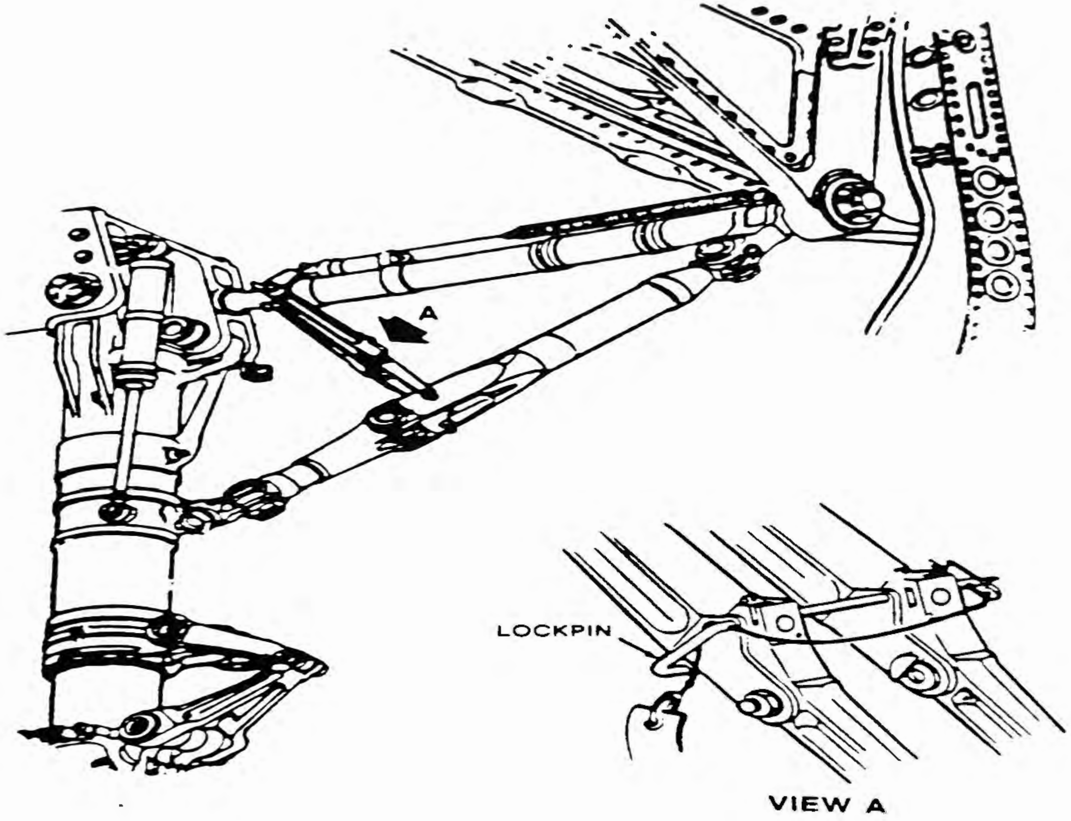


TURNING RADII CONDITIONS	MAXIMUM TURNING ANGLE	A WING TIP CLEARANCE	B HOR. STAB CLEARANCE	C RUNWAY WIDTH FOR 180° TURN
TOWING OR PUSHING BYPASS VALVE OPEN, TORQUE LINKS CONNECTED	57°	127' 0"	120' 0"	156' 0"
TOWING OR PUSHING, TORQUE LINKS DISCONNECTED	67°	111' 4"	110' 4"	132' 0"

TURNING RADII DC-8 MODEL 63

FTX80698

Figure 1-57

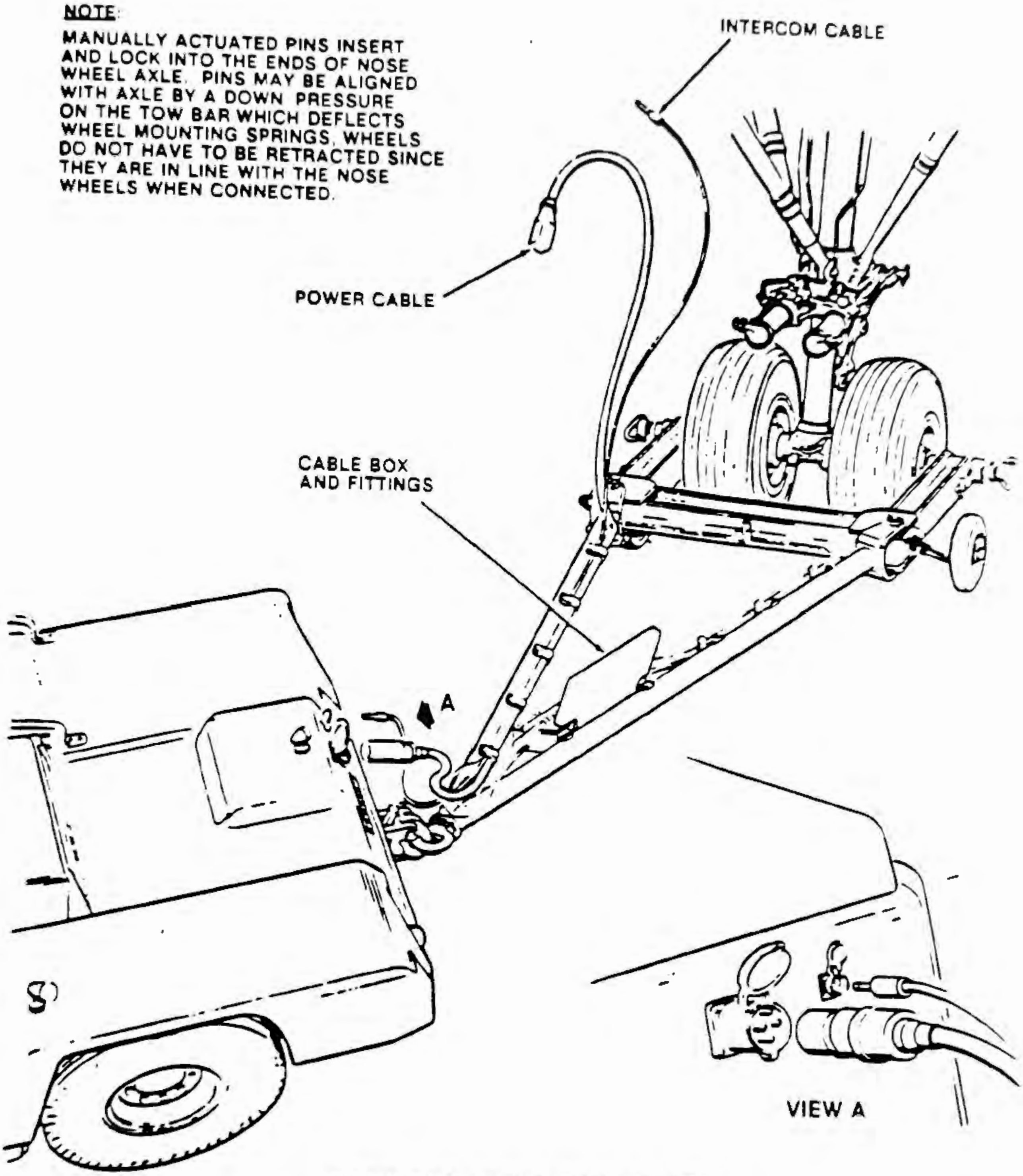


NOTE:
MAIN GEAR LOCKPINS SHOULD BE INSTALLED IMMEDIATELY UPON LANDING AND SHOULD REMAIN INSTALLED UNTIL THE ENGINES HAVE BEEN STARTED IN PREPARATION FOR TAKEOFF

MAIN GEAR GROUND LOCKPIN

Figure 1-58

FTX80700


NOTE:
MANUALLY ACTUATED PINS INSERT AND LOCK INTO THE ENDS OF NOSE WHEEL AXLE. PINS MAY BE ALIGNED WITH AXLE BY A DOWN PRESSURE ON THE TOW BAR WHICH DEFLECTS WHEEL MOUNTING SPRINGS. WHEELS DO NOT HAVE TO BE RETRACTED SINCE THEY ARE IN LINE WITH THE NOSE WHEELS WHEN CONNECTED.
INTERCOM CABLE
POWER CABLE
CABLE BOX AND FITTINGS
A
VIEW A

DRAW BAR CAPACITY 30.000 LBS
WITH A 3G SAFETY FACTOR

NOSE GEAR TOWING

FTX80701

Figure 1-59

(c) Disengage nosegear from steering cylinders to allow steering control by towbar as follows:

1 On airplanes not provided with a nosewheel steering bypass valve, disconnect nosegear torque links. Secure links in a strut compressed position.

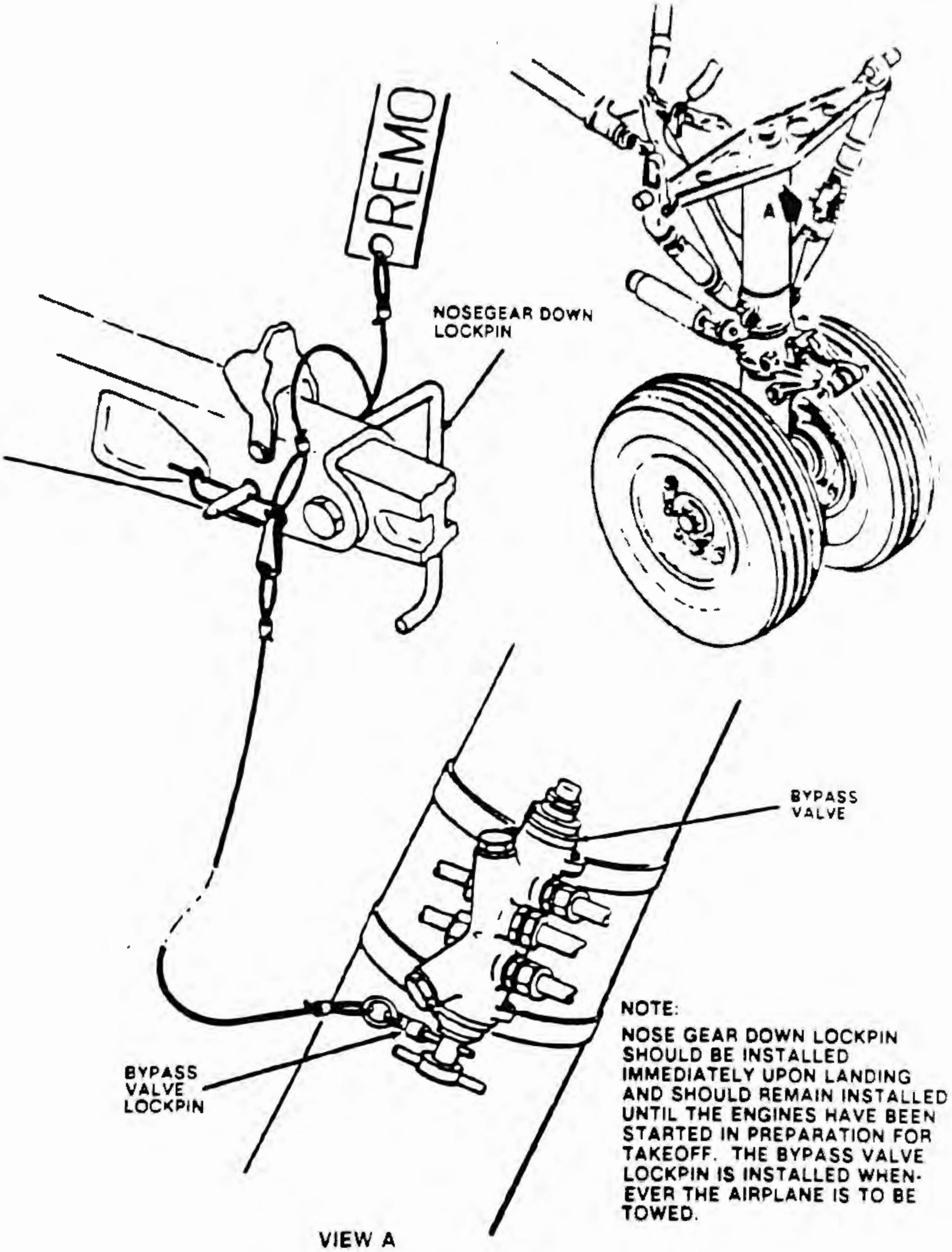
2 On airplanes provided with nosewheel steering bypass valve, place valve handle in open position and install lockpin (see Figure 1-60). If required, steering control by towbar may be accomplished with bypass valve in closed position by disconnecting nosegear torque links. Secure links in a strut compressed position.

(d) Make certain anti-skid switch is in off position.

WARNING: ANTI-SKID SWITCH MUST BE IN OFF POSITION DURING TOWING OPERATIONS TO PREVENT DEPLETING PRESSURE IN HYDRAULIC ACCUMULATORS AND SUBSEQUENT LOSS OF BRAKING CAPABILITIES. IF PRESSURE IS NOT AVAILABLE FOR USING AIRPLANE BRAKES IN AN EMERGENCY (TOW VEHICLE BRAKES FAIL OR TOW VEHICLE BECOMES DISCONNECTED), INJURY TO PERSONNEL OR DAMAGE TO EQUIPMENT COULD RESULT.

(e) Position towbar at nosewheel; insert pins into ends of nosewheel axle; and lock.

NOTE: Pins may be aligned with axle by a down pressure on the towbar which deflects wheel mounting springs. It is not necessary to retract the tow bar wheels.



NOTE:
NOSE GEAR DOWN LOCKPIN SHOULD BE INSTALLED IMMEDIATELY UPON LANDING AND SHOULD REMAIN INSTALLED UNTIL THE ENGINES HAVE BEEN STARTED IN PREPARATION FOR TAKEOFF. THE BYPASS VALVE LOCKPIN IS INSTALLED WHENEVER THE AIRPLANE IS TO BE TOWED.

NOSE GEAR GROUND LOCKPIN

FTX80699

Figure 1-60

(f) Connect towbar to tow vehicle.

(g) Connect power cable if electrical power for airplane lights, radio communications with control tower, or hydraulic pressure is required.

(h) Connect intercom cable is interphone communication is required.

(i) Station qualified person in captain's seat in flight compartment.

(j) Establish communications between tow vehicle and flight compartment either through airplane interphone system or by two-way radio (walkie-talkie).

(k) Pressurize airplane hydraulic system for brake pressure.

> NOTE: **When the system hydraulic pressure gage indicates 3000 psi, there is normally enough pressure in the accumulators for four brake applications. If the system pressure drops below 1000 psi, pressurize the system.**

(l) Station wing walkers to check clearance between airplane and adjacent equipment when moving airplane in congested areas.

(m) Make certain wheel chocks, static ground cables, and mooring cables have been removed.

(n) Release parking brakes by pressing either set of brake pedals. Parking brake knob will retract to off position.

(o) Establish radio contact with control tower for instructions when towing in taxi or takeoff areas.

(p) Tow airplane, making smooth starts and stops with two vehicle. Observe maximum turn restrictions.

(q) Set brakes when towing operation is complete by pressing either set of brake pedals and pulling parking brake knob out.

(r) Chock airplane wheels, and connect static ground cables to grounding provisions located on inboard engine cowlings (or in the main landing gear) and to apron grounding facility.

(s) Disconnect and stow power cable and intercom cable.

(t) Disconnect and remove towbar clear of airplane.

(u) Remove lockpin from nosewheel steering bypass valve (handle will return to normal (closed) position), and/or connect nosegear torque links.

WARNING: BEFORE REMOVING LOCKPIN, MAKE CERTAIN PERSONNEL AND EQUIPMENT ARE CLEAR OF NOSEWHEEL. REMOVING BYPASS VALVE LOCKPIN ALLOWS VALVE TO CLOSE AND HYDRAULIC PRESSURE TO CENTER NOSEGEAR WHEELS.

(2) Main Gear Towing (See Figure 1-61)

(a) Make certain landing gear ground lockpins are installed.

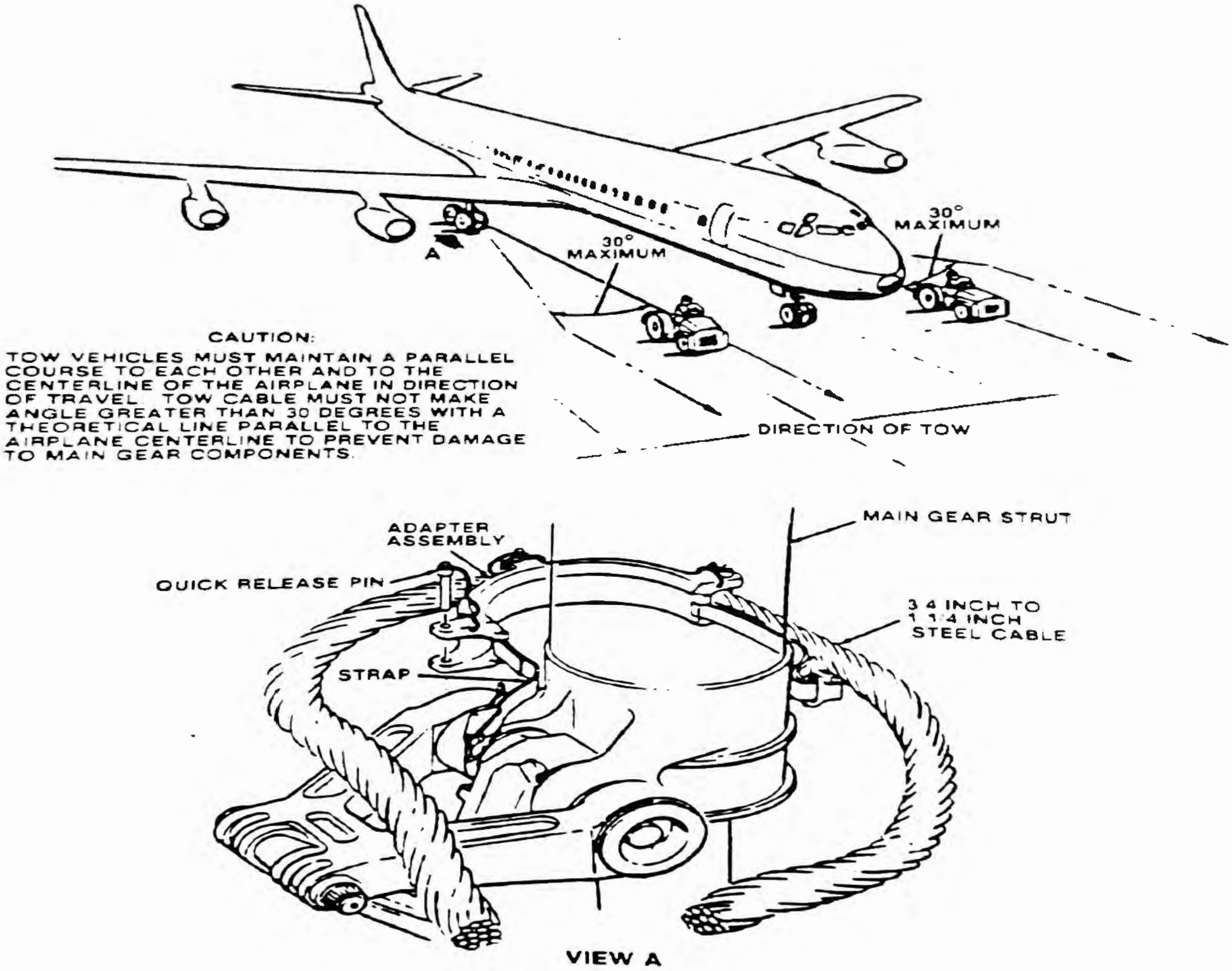
(b) Make certain landing gear control lever is in down position.

NOTE: Perform Step (3) if steering is to be accomplished using third vehicle.

(c) Disengage nosegear from steering cylinders to allow steering control by towbar as follows:

1 On airplane not provided with a nosewheel steering bypass valve, disconnect nosegear torque links. Secure links in strut compressed position.

2 On airplanes provided with a noswheel steering bypass valve, place valve handle in open position and install lockpin. If required, steering control by towbar may be accomplished with bypass valve in closed position by disconnecting nosegear torque links. Secure links in a strut compressed position.



CAUTION:
TOW VEHICLES MUST MAINTAIN A PARALLEL COURSE TO EACH OTHER AND TO THE CENTERLINE OF THE AIRPLANE IN DIRECTION OF TRAVEL. TOW CABLE MUST NOT MAKE ANGLE GREATER THAN 30 DEGREES WITH A THEORETICAL LINE PARALLEL TO THE AIRPLANE CENTERLINE TO PREVENT DAMAGE TO MAIN GEAR COMPONENTS.

MAIN GEAR TOWING

Figure 1-61

FTX80702

(d) Make certain anti-skid switch is in off position.

WARNING: **ANTI-SKID SWITCH MUST BE IN OFF POSITION DURING TOWING OPERATIONS TO PREVENT DEPLETING PRESSURE IN HYDRAULIC ACCUMULATORS AND SUBSEQUENT LOSS OF BRAKING CAPABILITIES. IF PRESSURE IS NOT AVAILABLE FOR USING AIRPLANE BRAKES IN AN EMERGENCY (TOW VEHICLE BRAKES FAIL OR TOW VEHICLE BECOMES DISCONNECTED), INJURY TO PERSONNEL OR DAMAGE TO EQUIPMENT COULD RESULT.**

(e) Install tow cable adapter on each main gear strut with casting facing aft.

(f) Pass cable around main gear strut, position it in adapter recess, and install quick-release pins.

(g) Secure free end of cable to standing part using cable clamps.

(h) Connect cables to tow vehicles. Make certain cables are of sufficient length to clear airplane, and that tow vehicles are operating on hard, firm surface.

WARNING: **BRIDGE CABLES WITH ROPE AT FREQUENT INTERVALS TO PROTECT PERSONNEL AND EQUIPMENT FROM WHIPPING ACTION IN EVENT CABLE SHOULD BREAK.**

(i) Connect power cable is electrical power for airplane lights, radio communications with control tower, or hydraulic pressure is required.

(j) Connect intercom cable is interphone communication is required.

(k) Station qualified person in captain's seat in flight compartment.

(l) Establish communications between tow vehicle and flight compartment either through airplane interphone system or by two-way radio (walkie-talkie).

(m) Pressurize airplane hydraulic system for brake pressure and nosewheel steering.

NOTE: **When system hydraulic pressure gage indicates 3000 psi, there is normally enough pressure in accumulators for four brake applications. If system pressure drops below 1000 psi, pressurize the system.**

(n) Station wing walkers to check clearance between airplane and adjacent equipment when moving airplane in congested areas.

(o) Make certain wheel chocks, static ground cables, and mooring cables have been removed.

(p) Release parking brakes by pressing either set of brake pedals. Parking brake knob will retract to the off position.

(q) Establish radio contact with control tower for instructions when towing in taxi or takeoff areas.

(r) Tow airplane either forward or backwards, making smooth starts and stops with tow vehicles. Do not exceed main gear towing limits.

WARNING: LOCK MAIN GEAR AFT BOGIE BEAMS WHEN TOWING AIRPLANE BACKWARDS TO AVOID CRITICAL LOADING OF MAIN GEAR.

NOTE: **Maximum main gear towing load limit, within 30 degrees of directly forward, is 81,000 pounds on each gear. Within 30 degrees of directly aft, maximum main gear towing load limit is 106,000 pounds on each gear.**

(s) Make certain tow vehicles exert an equal load on each main gear strut by following a parallel course and maintaining equal speed.

CAUTION: **TOW VEHICLES MUST MAINTAIN A PARALLEL COURSE TO EACH OTHER AND TO THE CENTERLINE OF AIRPLANE IN DIRECTION OF TRAVEL. TO PREVENT DAMAGE TO MAIN GEAR COMPONENTS, TOW CABLE MUST NOT MAKE AN ANGLE GREATER THAN 30 DEGREES WITH THEORETICAL LINE PARALLEL TO THE AIRPLANE CENTERLINE. COORDINATE MOVEMENT OF TOW VEHICLES TO PREVENT UNEVEN LOADS.**

(t) Steer airplanes by nosewheel steering control or by third vehicle. Brake airplane smoothly and evenly using airplane brakes.

(u) Set brakes when towing operation is complete by pressing either set of brake pedals and pulling parking brake knob out.

(v) Chock airplane wheels and connect static ground cables to grounding provisions located on inboard engine cowlings (or on main landing gear) and to apron grounding facility.

(w) Disconnect and stow power cable and intercom cable.

(x) Disconnect and remove tow cables clear of airplane.

(y) Remove tow cable adapters.

(z) Remove lockpin from nosewheel steering bypass valve (handle will return to normal (closed) position), and/or connect nosegear torque links.

WARNING: **BEFORE REMOVING LOCKPIN, MAKE CERTAIN PERSONNEL AND EQUIPMENT ARE CLEAR OF NOSEWHEEL. REMOVING BYPASS VALVE LOCKPIN ALLOWS VALVE TO CLOSE AND HYDRAULIC PRESSURE TO CENTER NOSEGEAR WHEELS.**

37. Parking and Mooring - Description

A. The airplane is normally parked or moored on a cement apron where the necessary mooring accommodations are available.

B. During normal weather conditions, the airplane should be parked using wheel chocks and parking brakes. Gust locks are installed on the rudder and elevator surfaces to prevent damage caused by sudden wind gusts. The dampers installed on the ailerons are designed primarily to dampen flutter during flight, but are also used as a resistance against sudden wind gusts.

C. During high wind conditions, the airplane should be moored to tie-down facilities on the apron.

38. General Servicing - Description

Particular attention has been given to airplane design with respect to furnishing the airplane with simplified servicing features compatible with ground servicing equipment currently in use.

39. Pressure Refueling

A. The airplane is equipped with four pressure refueling adapters; two in each wing, accessible through access doors located between the inboard and outboard pylons on the lower surface of each wing leading edge. The height from ramp level to the pressure refueling adapters, in either wing, is approximately 11 feet.

B. All four pressure refueling adapters tee into the crossfeed manifold which is common to all tanks. Single point pressure refueling of all tanks can be accomplished through any adapter in either wing or any combination of adapters can be used simultaneously to increase the fuel flow rate.

C. The initial fuel flow rate through each pressure refueling adapter is 350 gallons per minute at approximately 35 psi pressure. A maximum total initial refueling flow rate of 1400 gallons per minute is obtainable when pressure refueling through all four adapters simultaneously; however, irrespective of the number of adapters used, the fuel flow rate will decrease as the tank fuel level increase.

40. Gravity Refueling

A. The airplane is equipped with four overwing auxiliary (gravity) fill adapters; one for each main tank in either wing. The fill adapters are flush mounted with the wing upper surface.

B. Refueling the center wing, forward auxiliary, and No. 1 and No. 4 (outboard) alternate tanks is accomplished by transferring fuel from the main tanks.

C. The maximum fill rate through each auxiliary fill adapter is 250 gallons per minute. Two or more tanks can be refueled simultaneously, as required, depending on available ground fueling equipment.

41. Fuel Quantity Measuring Sticks

A. The fuel quantity measuring sticks are the magnetic dripless type consisting of a mounting, a tube housing, an inner tube (measuring stick) graduated for calculation of fuel tank quantity, and a circular float. The float is installed on the tube housing and is free to move up and down with the fuel level in the tank.

B. Checking the fuel level within the fuel tank is accomplished by extending the inner tube (measuring stick) downward until a magnet installed in the top of the stick is coupled with magnets in the circular float assembly. When the stick is magnetically coupled to the float, the stick is positioned relative to the fuel level in the tank. A force of 5 ounces (minimum) is required to break the magnetic coupling between the stick and float.

C. The stick is unlocked (released) or locked (stowed) by depressing the stick latch and turning the latch 90 degrees in either direction. A flat bitted screwdriver can be used to depress and turn the latch. The operating procedures for all measuring sticks are identical.

42. Defueling

A. The fuel tanks can be defueled individually or simultaneously, as required, by opening the respective tank selector and crossfeed valves and using the fuel boost pumps to pump fuel through the crossfeed manifold and pressure refueling (defueling) adapters into ground fuel units or a fuel dump. If electrical power is not available for boost pump operation, ground fuel unit negative pressure (suction) may be used to draw fuel from the tanks.

B. Two pressure refueling adapters are provided in each wing. The adapters are located between the inboard and outboard engine pylons on the lower surface of each wing leading edge.

C. All four pressure refueling adapters tee into the crossfeed manifold which is common to all tanks. Single point defueling of all tanks can be accomplished through any adapter in either wing or any combination of adapters can be used simultaneously to increase the defueling flow rate.

43. Fuel Tank Sump, Vent System, and Fill Line Sump Drain

A. The centerwing auxiliary tank sump drain valves are the spring-loaded ballcock type and are accessible through an access door on the bottom of the wing.

B. The vent system manifold drain valves are located, one each, forward in the No. 2 and 3 main (inboard) fuel tanks.

C. The outboard alternate fuel tank fill line sump drain valves are located, one each, between the No. 1 and 4 (outboard alternate) fuel tank sump drain valves.

D. With the exception of the center auxiliary tank drain valves, all drain valves operate identically and are mounted flush with the wing lower surface.

44. Engine Oil System

The engine oil tank fill port and drain provisions are located on the forward upper left side of the engines. The oil tank gravity fill ports are accessible through the oil tank service access doors. The oil tank drain valves are accessible through the engine left forward cowl doors.

45. Engine Starter

The starters are located on the lower left side of the engines and are accessible through the left forward cowl doors.

54. DC-8-63 Cargo Loading System

A. The "C" Container Loading System is a low friction, non-powered, detachable system of conveyors and restraints, of minimum weight, which mounts in tiedown tracks and receptacles in the airplane flooring. It is designed so that cargo can be received at either the forward or rear passenger entrance door.

B. The system is comprised of side rail assemblies, side restraint latches, end restraint fittings, and a forward cargo barrier net.

C. This system will be easily removable, to allow for installation of the Douglas Universal Cargo Loading System.

55. Douglas Universal Cargo Loading System

A. Introduction

(1) The Douglas Universal Cargo Loading System is a low friction, non-powered, detachable system of conveyors and restraints, of minimum weight, which mounts in tiedown tracks and receptacles in the airplane flooring. It is designed so that cargo can be received at the threshold of the main cargo door and easily rolled to desired positions in the main cabin. Cargo is carried on pallets, with the system having accommodations for 18 pallet positions.

(2) The system is comprised of ball transfer conveyor assemblies, roller conveyor assemblies, side rail assemblies, side restraint latches, door sill conveyors, end restraint fittings, and a forward cargo barrier net. A ventilation curtain (smoke barrier) is also installed and serves to reduce the ventilation rate between the cargo compartment and occupied areas.

(3) The system is designed to accommodate the transportation of all known common sizes and type of aircraft cargo pallets, both Military and Commercial, and may be installed in place of the "C" container loading system.

46. Constant Speed Drive (CSD) Transmission

A. The CSD transmissions are located below the engines and are mounted on the forward side of the engine accessory drive case.

B. The output spline cavity serves as an oil reservoir for the generator lubrication system. The generators are self lubricated and do not require lubrication servicing other than maintaining an adequate oil supply in the output spline cavity.

47. Hydraulic Reservoir

The main reservoir fluid level sight gauge is mounted on the reservoir which is accessible through the left main gear wheel well and an access door on the bottom of the wing. The sight gauge on the reservoir will indicate the correct fluid level in the reservoir, but only with the hydraulic system in a prepared condition as outlined in the preliminary procedures. The external hydraulic ground power/pressure fill connections are accessible through the access door.

48. Ground and Lateral Control Spoiler System Hydraulic Reservoir

The ground and lateral control spoiler system is a closed hydraulic system equipped with an independent system-pressurized reservoir. The system reservoir is located aft and inboard in the right main gear wheel well.

49. Equipment and Furnishings - Introduction

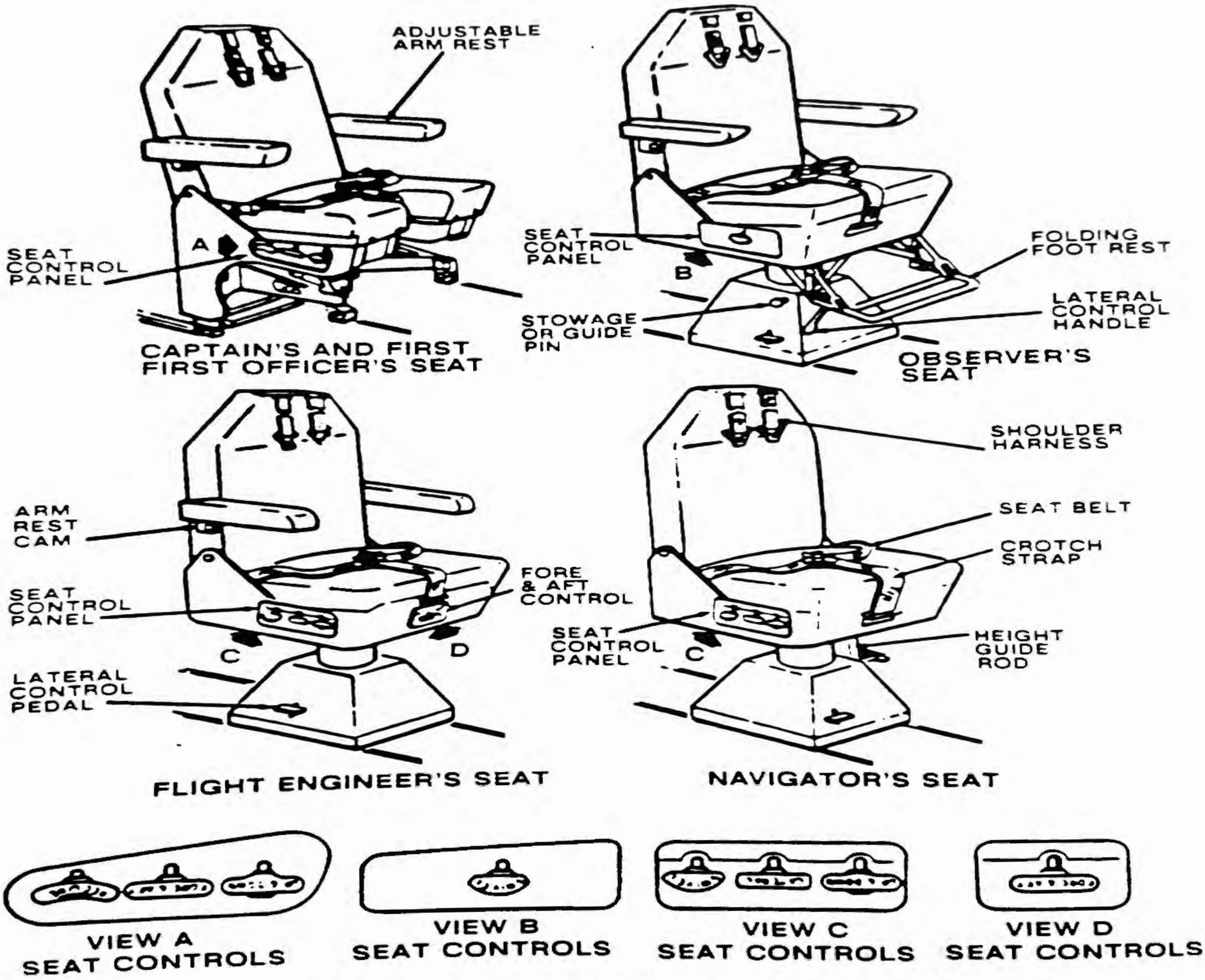
A. The interior of Airborne Express's DC-8's is arranged for all-cargo operation by the installation of a container loading system unique to Airborne's aircraft.

B. Cargo configured aircraft have one lavatory mounted in the forward section of the aircraft..

C. Stowage for all necessary emergency equipment is provided throughout the flight compartment and cabin.

50. Flight Compartment Seats (See Figure 1-62)

A. The flight compartment is equipped with five different types of seats which are the Captain's and First Officer's seat, the Flight Engineer's seat, the first observer's seat, the second Observer's seat and the Courier seat. The



FLIGHT COMPARTMENT SEATS

FTX80900

Figure 1-62

Courier seat is of a completely different design and will be discussed later in this chapter. All seats are upholstered with a flame resistant material. that is removable for cleaning and repairs. Each seat is equipped with a seat belt, shoulder harness, and inertial reels. The seat belts are adjustable and are equipped with a rotary type quick release buckle. The shoulder harness is attached to inertial reels that are located in the seat back. The inertial reels permit the occupant to move forward as desired and take up the slack when the occupant moves back. When side loads of more than 1G are exerted on the harness, the reels lock automatically, preventing the occupant from moving forward.

NOTE: If an inertial reel locks automatically due to acceleration forces or due to testing the reels, it will be necessary to release the forward tension by moving the harness aft towards its stowed position to unlock.

B. The Captain's and First Officer's seats are mounted on seat tracks and are identical except for the location of the seat adjustment controls. The controls are located on the right side of the Captain's seat and on the left side of the First Officer's.

C. The seats can be adjusted for height, horizontal position and seat back angle. To find the proper seat adjustment and reference eye location, it is recommended that the Pilot occupy the seat and adjust the seat back for desired angle. Then position the seat fore and aft to be comfortable positioned at the controls. Vertical adjustment should result in sighting tangentially along the top of the glareshield.

D. The seats for the Flight Engineer and the Observer have pedestal-type bases and are mounted in floor tracks. The Flight Engineer seat is equipped with foldable armrests to allow access to the seat. The seat can be adjusted for height and swivel, fore and aft, and lateral movement. The seat normally faces outboard and will swivel 90 degrees to a forward facing position. The observer seat has armrests, and can be adjusted for height, seat back angle, swivel, and lateral movement. The footrest is non-adjustable and is held up by spring pressure. The second observer's seat can be adjusted for height, lateral and swivel movement.

E. The seat for the courier is a folding type seat and has no adjustments. The seat has a clasp type seatbelt with a fixed shoulder harness (no inertial reel). There is a compartment beneath the seat which contains the life preserver for that occupant.

51. Crew Galleys

A. The crew galley is attached to the rear coat closet wall forward of the crash barrier net. It is equipped with two liquid containers, a storage compartment, and a trash can.

B. The one liquid container has a capacity of two gallons, and is not heated. The smaller container or hot cup has a capacity of approximately one quart and is heated.

C. Electrical power is supplied from one 25-amp circuit breaker on the 28VDC-1 bus.

52. Waste Disposal System

A. The toilet assembly is a self-contained, electrically operated, recirculating, flush-type unit. The waste tank is charged with a chemical-water solution for toilet bowl cleaning. The chemicals used in the charge solution serve to disinfect and color the solution and eliminate offensive odors.

B. The water pump is mounted in the toilet waste tank cover and consists of an impeller type pump and motor assembly and is powered from the 28VDC-1 bus. The pump delivers filtered water to the toilet bowl unit during each flush cycle. The flushing cycle begins when the toilet lid is closed. The toilet assembly is enclosed in a metal container that is located on the right hand side just forward of the Cargo Barrier net.

53. Cargo Loading System

A. The Container Loading System is a low friction, non-powered, detachable system of conveyors and restraints, of minimum weight, which mounts in tiedown tracks and receptacles in the airplane flooring. It is designed so that cargo can be received at either the forward or rear passenger entrance door.

B. The system is comprised of side rail assemblies, side restraint latches, end restraint fittings, and a forward cargo barrier net.

B. Ball Transfer Conveyor Assemblies

Twelve-ball transfer conveyor assemblies are used in the area occupied by pallet position two and three. The ball transfer conveyors are used to afford transition from lateral to fore and aft movement of the pallets.

C. Roller Conveyor Assemblies

To provide low friction fore and aft movement of pallets, roller conveyor assemblies are used. The assemblies are constructed of aluminum alloy channels of various lengths to which roller assemblies are attached. The roller assemblies offer maximum rolling surface with minimum equipment weight.

D. End Restraint Fittings

The retractable end restraint fittings are of two basic models, those with rollers on each end of the base, and those without rollers. Those assemblies without rollers are used in the open areas of the ball transfer conveyor assemblies. Those assemblies with rollers are used in other positions, except where rigid end restraint fittings are used; the rollers providing additional rolling surface to reduce friction when pallets are moved fore and aft.

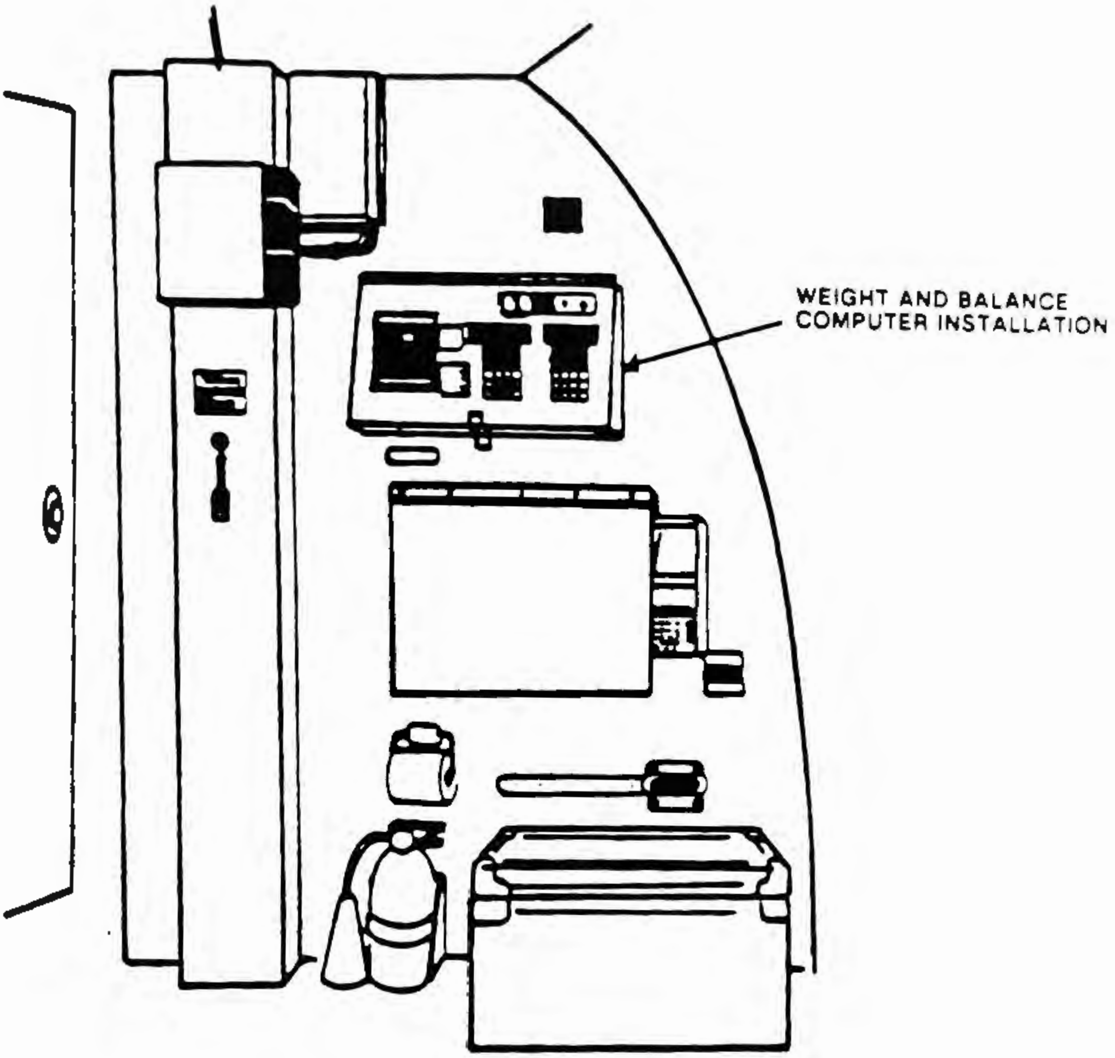
E. Side Rail Assemblies

For side restraint of pallets, side rail assemblies are used (except in the LH side of the airplane in ball transfer conveyor assemblies where side restraint is accomplished by latches which are an integral part of the ball transfer conveyor assemblies) and in positions 1 thru 17 which are adjustable to accommodate various pallet/aisle combinations.

56. Weight and Balance Computer System - Description and Operation

A. General

The weight and balance computer system is used to calculate cargo loading. The system is mounted to the forward right-hand side of the cargo compartment (See Figure 1-63). The system consists of a lockable weight and balance computer assembly that contains the following: two TI-78 computers, thermal printer, level converter, power supply, two relays and a heater pad.



LOCATION OF WEIGHT AND BALANCE COMPUTER SYSTEM

FTX80703

Figure 1-63

B. Description of Weight and Balance computer System Components (See Figure 1-64)

(1) Computers

The two computers are Texas Instruments TI-78 handheld computers. The TI-78 computer utilizes an 80C88 16-bit micro-processor, backed by 64K bytes of system ROM and 256K bytes of RAM. The display is a backlighted liquid crystal display and the keyboard contains 39 phosphorescence illuminated key buttons.

(2) Thermal Printer

The thermal printer is a modified DPU-411 Type II printer. The DPU-411 Type II prints data input by the serial RS-232C method, on thermal paper.

(3) Level Converter

The level converter connects the TI-78 computer to the thermal printer. It transforms the CMOS signal level of the TI-78 to the RS-232C level of the printer. The level converter receives power from the TI-78.

(4) Power Supply

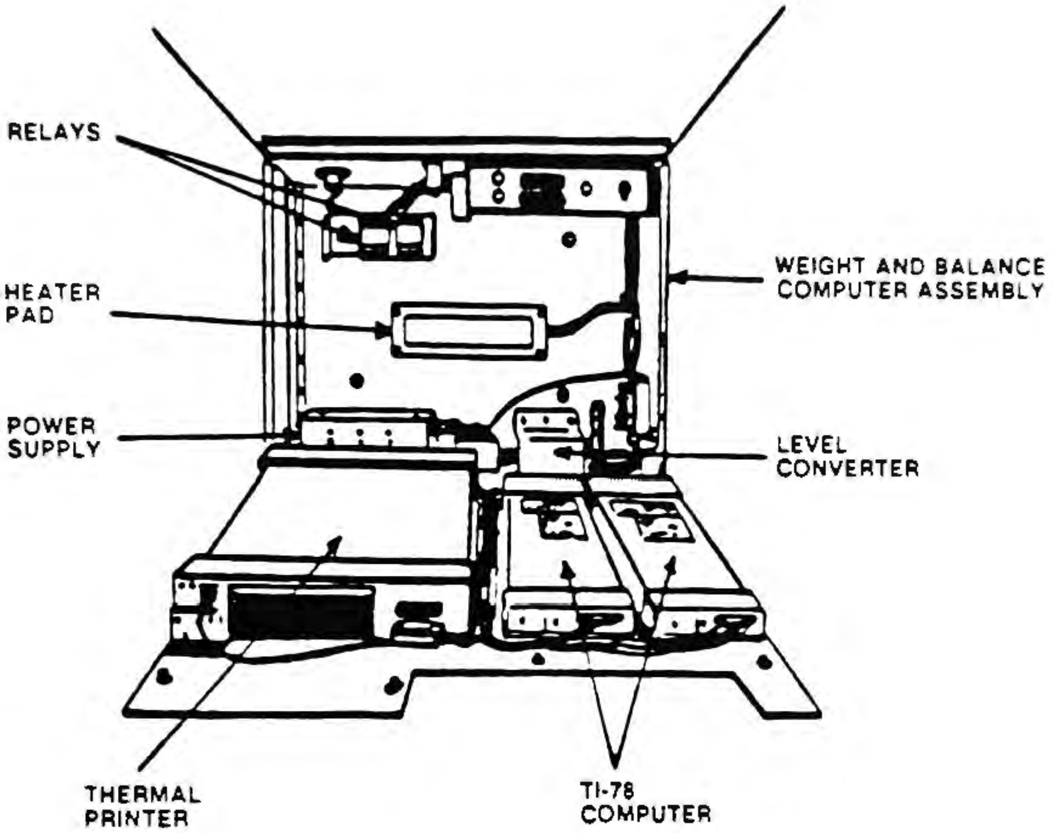
The power supply provides the necessary power for the electrical components. It is a regulated DC to DC power converter which takes 28 VDC aircraft power and converts it to 5 VDC system power. The operation of the power supply is controlled by the guarded POWER ON/OFF switch.

(5) Relays

The two relays determine which of two TI-78 computers are connected to the system. The operation of the relays is controlled by the ILN/OTB switch. OTB is selected in the relay de-energized state.

(6) Heater Pad

The computers and printer are sensitive to cold weather. For this reason, the weight and balance computer assembly holding the units



LOCATION WEIGHT AND BALANCE COMPUTER SYSTEM COMPONENTS

FTX80704

Figure 1-64

has a heating pad. The heating pad must be used prior to operating the computers and printer in temperatures below 40°F. It takes approximately two minutes for heater to warm the unit. The operation of the heater pad is controlled by the guarded HEATER ON/OFF switch and a thermal switch. The thermal switch prevents the heater pad from operating when temperatures are above 40°F.

(7) Weight and Balance Computer Assembly

The weight and balance computer assembly is a lockable metal box with a transparent protective cover. It contains all the components of the weight and balance computer system.

B. Operation

The weight and balance data is entered into the weight and balance computer system each time cargo or fuel is loaded or unloaded from the aircraft prior to take-off. The operator enters appropriate weight data into the TI-78 computer which stores the information in memory. The computer labeled ILN is assigned for use by Wilmington personnel to create a load plan for even-numbered flights. The computer labeled OTB (for outboard) is assigned for use by personnel at an originating field location to create a load plan for odd-numbered flights. At the end of the weight and balance calculations, a tape is then printed which provides a permanent record of the weight and balance data. Turn stations loading or unloading would access the appropriate menus and modify the existing load plan to reflect revisions to the main deck weights, belly weight, and fuel.

NOTE: **If the program for the assigned computer is accidentally erased or the unit is damaged, the other computer may be used. The Avionics Department at ILN must be notified to repair or reprogram an inoperative computer.**

57. Emergency Equipment - Introduction

Emergency equipment for the crew and courier on Airborne Express aircraft includes escape tapes or ropes, life vests, oxygen, first aid kit, fire extinguishers, and a crash axe. If the aircraft is going to be operated international and overwater then two six man life rafts and an emergency radio beacon will be installed.

58. Escape Tapes and Ropes

A. ESCAPE TAPES are located above and slightly aft of each CLEARVIEW (sliding) WINDOW in the cockpit to enable the crew to evacuate the aircraft via a window, to enter a raft, or get down to the ground.

B. Two ESCAPE ROPES are installed in the cabin. One is overhead and aft of the main entrance door in a pouch and the other is located just aft of the aft entrance door in a similar pouch. The ropes have knots tied in them to improve exiting the aircraft in an emergency.

59. Crew Life Rafts

A. Two types of crew life rafts may be installed on ABX aircraft. Both have a six-man capacity and are designed to be ejected through the DC-8 Clear-view (sliding) window.

B. One type of raft consists of a single inflatable tube and inflatable canopy supports. When the raft is inflated by the CO2 bottle or manually the canopy supports are also inflated. Another type consists of a single inflatable tube with a fabric canopy. The rafts are contained in a packing case which is secured with breakaway straps that will break and allow the raft to inflate when the inflation handle is pulled.

C. If the raft inflates upside down there are righting handles on the underside which are used to turn the raft over.

D. A waterproof accessory kit is packed within the raft as a separate package and is secured to the raft by a line.

E. All accessories include instructions for use.

cylinder. Should the cylinder pressure exceed approximately 2650 psig, a blowout-type disc located in the hand-operated shutoff valve of the cylinder will rupture, allowing the oxygen to escape through a vent line and be dumped overboard through a green plastic inspection disc. Absence of this disc requires inspection of the system. The hand-operated shut-off valve and direct-reading cylinder pressure gauge assembly are screwed onto a fitting on the end of the cylinder.

(2) Crew Oxygen Cylinder Regulator (See Figure 1-68)

The crew oxygen cylinder regulators are attached to the crew oxygen cylinders by means of a union to the cylinder shutoff valve. The cylinder pressure regulator consists of a housing, a bellows and guide assembly, a regulating spring, and a poppet-type valve assembly. The regulator serves to reduce the original cylinder pressure of 1850 (+ 0. -20) psig to a line pressure between 150 and 50 psig, depending upon the pressure remaining in the cylinder. A direct-reading cylinder pressure gauge is threaded into the high-pressure side of the cylinder pressure regulator. Pressure regulation is accomplished by applying a high pressure against a small area and a low pressure against a large area. The high pressure source is the cylinder pressure, which acts against the poppet valve. The low pressure is the reduced pressure within the housing downstream of the poppet valve, which acts against the bellows and guide assembly. The restricted flow past the poppet valve causes pressure reduction in the housing. As the cylinder pressure decreases the outlet pressure also decreases to provide a proportional reduction in the line pressure.

(3) Diluter-Demand Regulators (See Figure 1-69)

(a) A diluter-demand regulator is located at each flight crew station in the airplane. A crew member is able to turn the system on and off, select 100 percent pure oxygen or oxygen mixed with air, test the mask for proper functioning, and mechanically select positive pressure to the mask, in the event of failure of the automatic function of the regulator.

(b) The front face of the regulator unit has three toggle-type selector valves. One is marked off-on, the second is marked normal oxygen - 100 percent oxygen, and the third is marked emergency, normal, and test mask. An indicator is included on the face of the regulator with dial markings to indicate the amount of oxygen

60. Life Raft Contents

The contents given below are the minimum requirements for a life raft when the aircraft is operating in tropical or frigid water areas. These quantities may be increased or items may be added.

RAFT ACCESSORIES

Mooring Line
Sea Anchor
Heaving Trailing Line
Accessory Case Tie-Down
Carrying Case
Knife, Hook Type
Locator Light
Canopy Assembly
Bailing Bucket
Repair Kit

Inflation Pump & Hose

SURVIVAL EQUIPMENT

Signal Flares, Day-Night
Survival Manual
Sponge
Mirror, Signal
First Aid Kit
Police Whistle
Knife, Scout
Dye Marker
Drinking Water/32 oz. treated*
Flashlight, Water Activated or canned life sticks**

* A desalt kit may be substituted for the 32 oz. of water.

** Water activated lights are being replaced with canned lite sticks at raft overhaul.

61. Adult Life Vest

A. The yellow-colored vest is packed in a clear, plastic bag that has an inspection tag attached, showing inspection data.

B. The vest is designed to provide an almost vertical flotation attitude. It is of the reversible style, allowing full access to the CO_2 cylinder release lanyards or the oral inflation tubes situated between the cells on each side. Waist straps are provided. Instructions for donning the life vest are printed on the back flap of the adult vest.

C. Do Not inflate life vests until after evacuating aircraft.

(1) Oral Inflation Tube

Each cell of the life vest has an oral inflation tube. To inflate, simply blow into the mouthpiece. To deflate, press the valve stem with a fingertip.

(2) Survivor Locator Lights

This light is mounted on the life vest and will be on the user's right or left shoulder, depending on which way he puts on the vest. The light is powered by a small water-activated battery attached to the waist strap. The battery has a hole in each side for admitting water. Two plastic plugs, attached to the battery by a common cord, are used for sealing the holes. When the plugs are removed and the battery submerged, the light will come ON. In this state the battery has a life of eight hours. Therefore, the passengers should be informed:

At Night: pull plugs out before ditching.

Daytime: in raft or in water, do not pull plugs out until just before dark.

(3) Inflation Cells

The adult vest has two cells with provisions for use of a CO2 cylinder or an oral tube to inflate each cell.

(4) CO_2 Cylinders

Each vest is provided with a CO2 cartridge for each cell. A lanyard with a red knob is attached to the trigger mechanism. To inflate the cell, pull smartly downward on the red knob.

62. First Aid Kits

The FAA-required (blue) First Aid Kits for each airplane are carried in the cockpit on all aircraft.

63. First Aid Kits - Contents

16 - Adhesive bandage compresses, 1'
20 - Antiseptic Swabs, 10MM
10 - Ammonia Inhalants, 6MM
8 - Bandage Compresses, 4'
5 - Triangular Bandage Compresses, 40?
6 - Burn Compound, 1/8 oz or an equivalent of another burn remedy
1 - Arm Splint, Non-Inflatable
1 - Leg Splint, Non-Inflatable
4 - Roller Bandage, 4'
2 - Adhesive Tape, 1' standard roll
1 - Pair scissors

64. Crash Axe

One crash axe is carried in the cockpit area. The axe can be used to provide holes in the aircraft in the event the exits should jam. If it becomes necessary to use the axe, it should be used between the windows or doors, or at the ceiling. It should not be used adjacent to windows or doors as the structure is heavier in these areas. The handle is insulated with rubber to prevent electrical shock should the axe contact electrical wires.

65. Emergency Radio Beacon (if installed)

A. One radio beacon is provided in the cockpit area. This radio transmits a homing beacon on the VHF civilian distress frequency of 121.5 megahertz and 243 megahertz on the UHF military distress frequency. This radio has a range of 200-300 miles depending on altitude of receiver and providing there are no interfering obstacles (mountains), and will last for over 50 hours. Power is supplied by water-activated batteries.

B. To operate the radio, simply tie the lanyard to the raft and place the radio in the water. The radio will then float. Water seeping into the radio at the bottom will activate the batteries and the radio will begin transmitting automatically. In the event of a crash landing on land, the radio can be used by pouring water, coffee, etc., into the boot over the lower end. The boot is found under the wrapped lanyard.

NOTE: **On some aircraft the Emergency Radio Beacon may not be located in a raft, but on the wall to the right of the Flight Engineer's Panel (if installed).**

66. General - Maintenance Practices

A. General

(1) The crew oxygen cylinders are located in the forward cabin ceiling, left side, adjacent to the forward entry.

(2) The protective breathing equipment (PBE) is located in the coat closet and is mounted to the AFT EPC panel.

B. Inspection/Check Oxygen Cylinder Pressure

(1) Check Crew Oxygen System Cylinder Pressure

Check reading on oxygen cylinder pressure gauge. When cylinder is full, gauge should indicate 1850 (+0, -20) psig at 70°F (see Figure 1-65).

67. Crew - Description and Operation

A. General (See Figures 1-66 and 1-67)

The crew oxygen system is a variable line-type system which includes two oxygen supply cylinders, two system pressure regulators, six diluter-demand control panels, four oro-nasal masks with integral microphones, and two oro-nasal masks without microphones.

B. Description

(1) Crew Oxygen Cylinder

The system is supplied from two high-pressure oxygen cylinders located in the forward cabin ceiling and held horizontally on mounting brackets with strap clamps. The cylinders have a capacity of 111 cubic feet and weigh approximately 44 pounds each. Under normal atmospheric conditions, pressure in a fully charged cylinder is 1850 (+0, -20) psig. A safety provision for thermal expansion is included for the

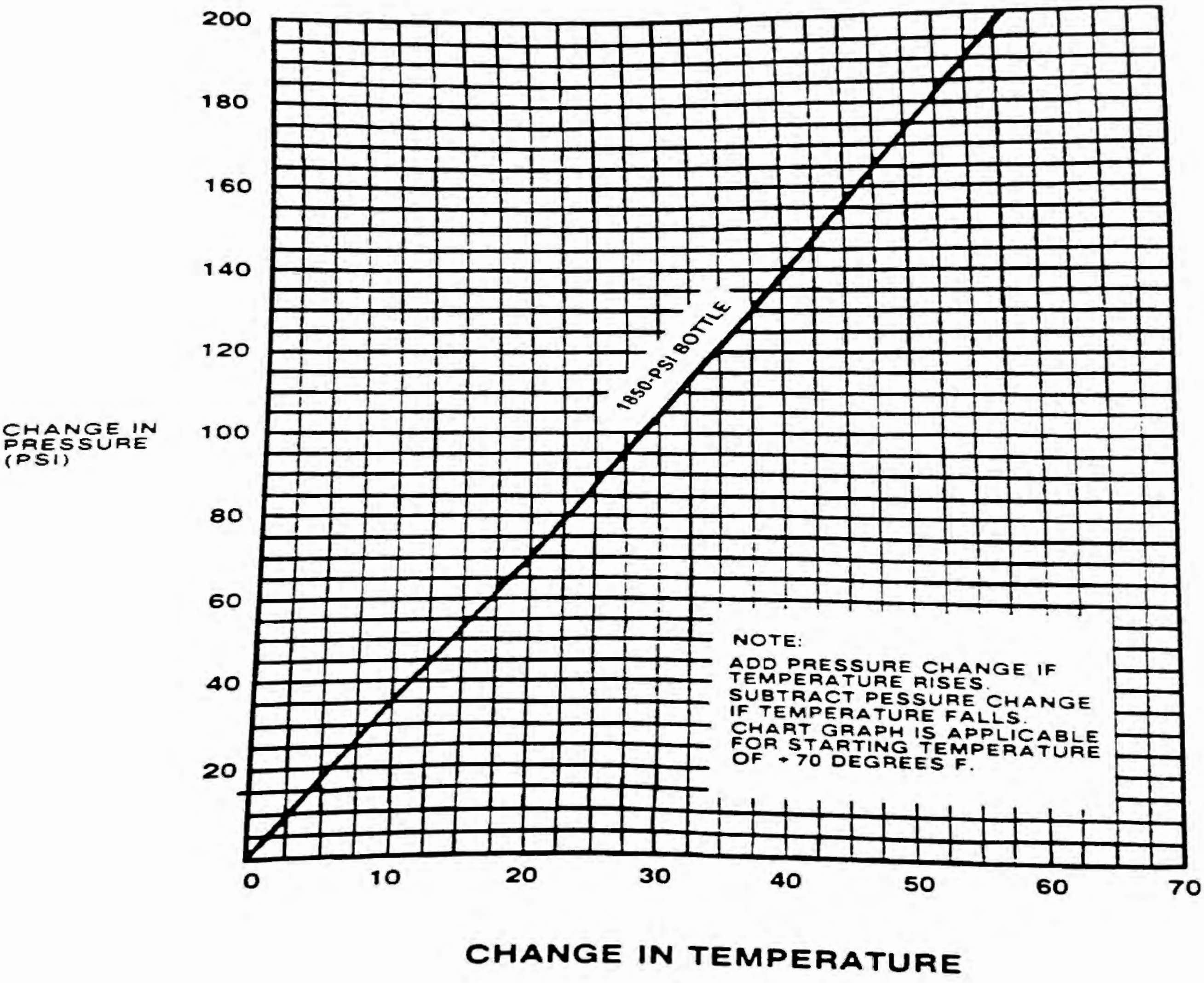
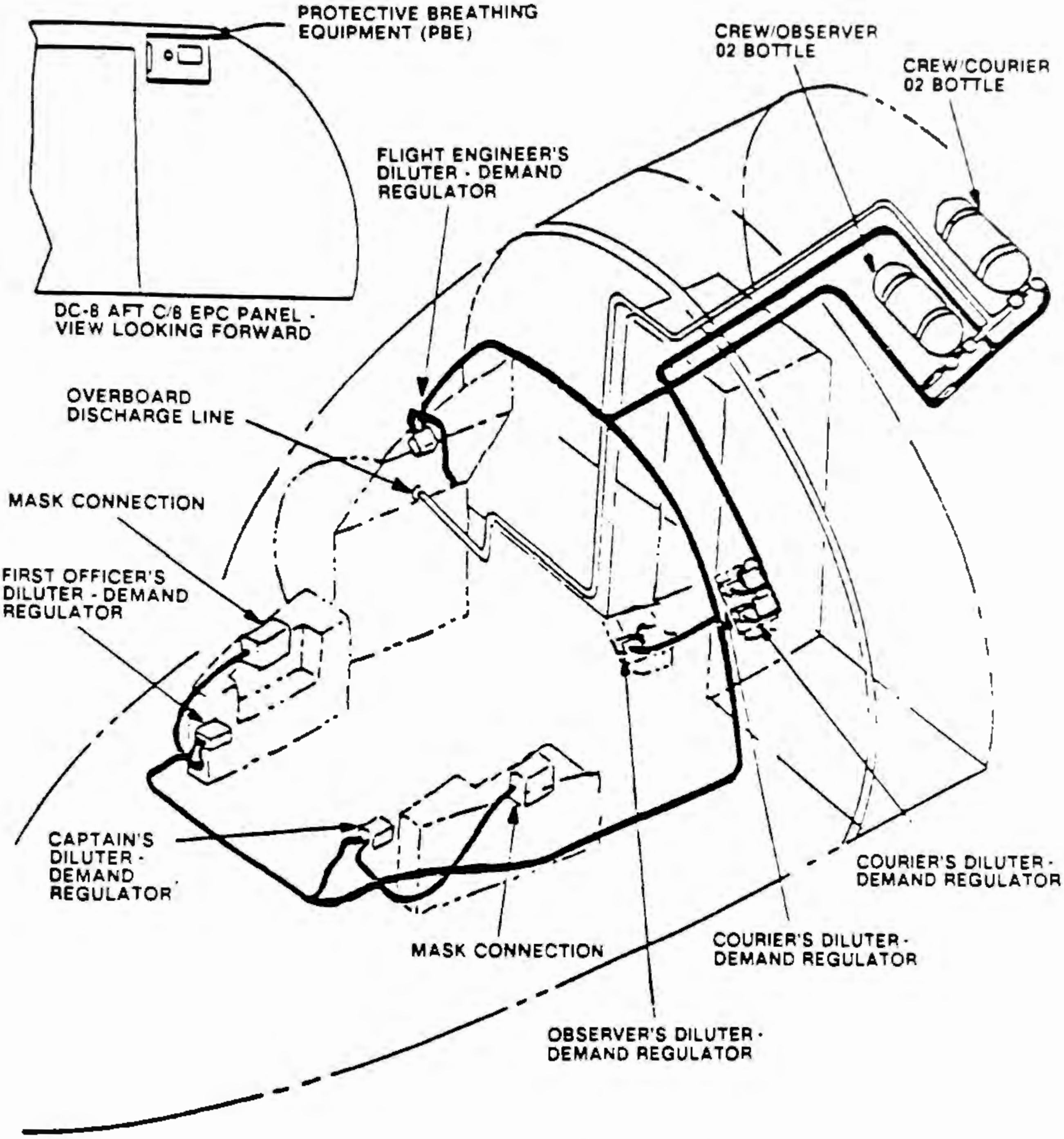

200
180
160
140
120
100
80
60
40
20
CHANGE IN PRESSURE (PSI)
1850-PSI BOTTLE
NOTE:
ADD PRESSURE CHANGE IF TEMPERATURE RISES.
SUBTRACT PESSURE CHANGE IF TEMPERATURE FALLS.
CHART GRAPH IS APPLICABLE FOR STARTING TEMPERATURE OF +70 DEGREES F.
0
10
20
30
40
50
60
70
CHANGE IN TEMPERATURE
FTX80705

Figure 1-65


PROTECTIVE BREATHING EQUIPMENT (PBE)
CREW/OBSERVER 02 BOTTLE
CREW/COURIER 02 BOTTLE
FLIGHT ENGINEER'S DILUTER - DEMAND REGULATOR
DC-8 AFT C/B EPC PANEL - VIEW LOOKING FORWARD
OVERBOARD DISCHARGE LINE
MASK CONNECTION
FIRST OFFICER'S DILUTER - DEMAND REGULATOR
CAPTAIN'S DILUTER - DEMAND REGULATOR
MASK CONNECTION
COURIER'S DILUTER - DEMAND REGULATOR
COURIER'S DILUTER - DEMAND REGULATOR
OBSERVER'S DILUTER - DEMAND REGULATOR

CREW OXYGEN SYSTEM - INSTALLATIONS

FTX80706

Figure 1-66

The greater the pressure against the diaphragm, the greater the opening of the demand valve. The air/oxygen mixture is controlled by the diluter assembly.

(g) When the selector toggle is in the 100 percent oxygen position, the gate valve is fully closed, and, although the aneroid unit keeps sensing, ambient air is not permitted to enter the system.

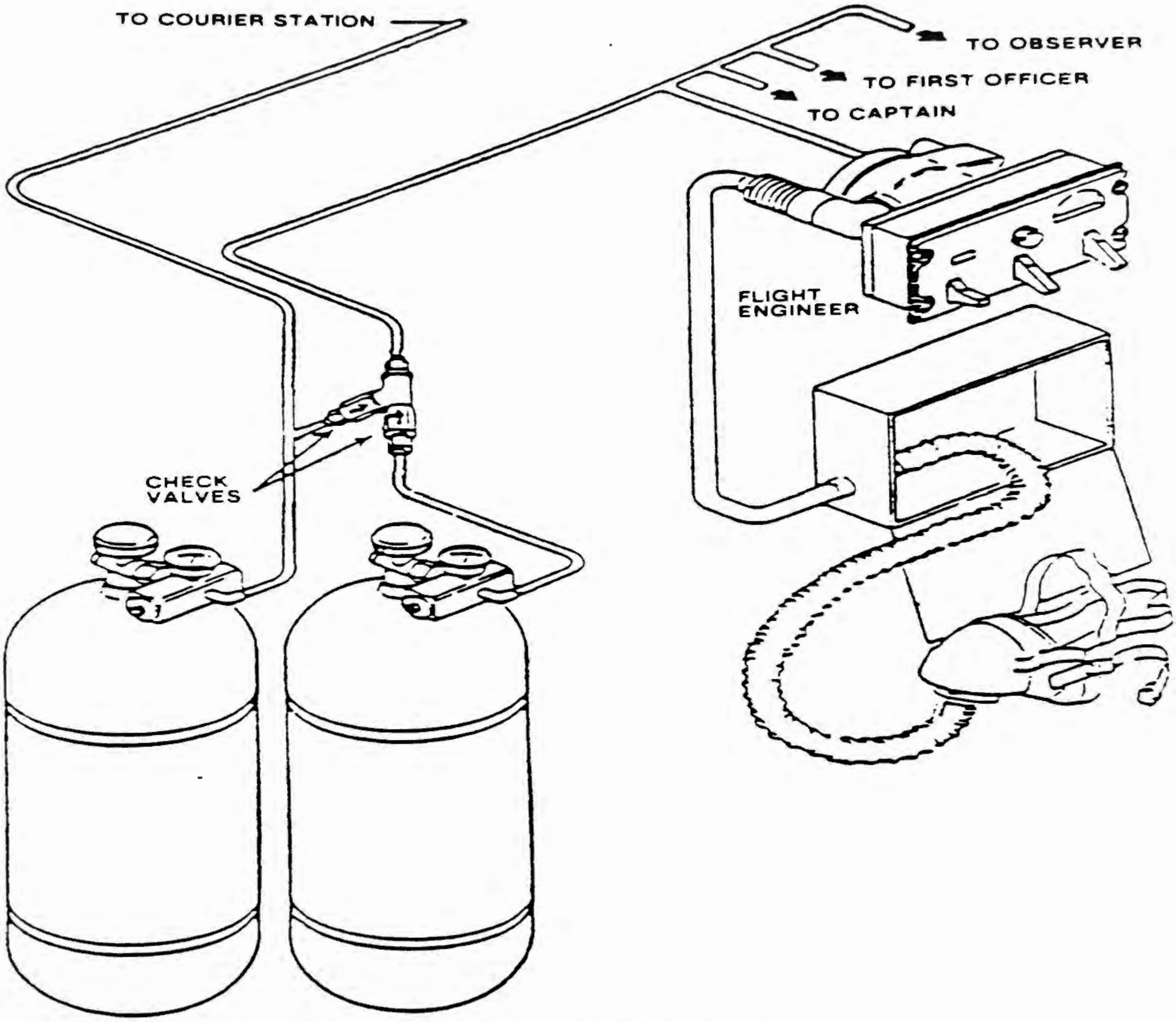
(h) Should cabin decompression occur above 28,000 feet, the pressure-breathing assembly automatically keeps the demand valve open, supplying positive pressure to the mask. This assembly consists of an aneroid, a spring, and a diaphragm. Should high-altitude decompression occur, the aneroid senses the change in the cabin pressure and moves against the spring-loaded diaphragm, opening the valve and permitting a constant flow of oxygen to the double diaphragms. This holds the demand valve open, supplying immediate positive pressure to the mask until the airplane is below 28,000 feet.

(i) Should the automatic sensing element fail to function, the demand valve can be opened mechanically by pushing the emergency toggle to the emergency position. A guard and safety pin are installed to prevent the emergency toggle from accidentally being placed in the emergency position. The safety pin must be removed before the toggle can be placed in the emergency position. Removal of the safety pin mechanically pushes both diaphragms upward, which, in turn, opens the demand valve. The other position of this toggle switch, the test mask position, is a spring-loaded position and must be held down to be effective.

(4) Oxygen Masks

(a) One oxygen mask is located at each flight crew station. The mask is an oro-nasal type which fits over the nose and mouth only. The part which fits over the nose and mouth (mask housing) is made of plastic with a rubber face gasket seal between the housing and the face.

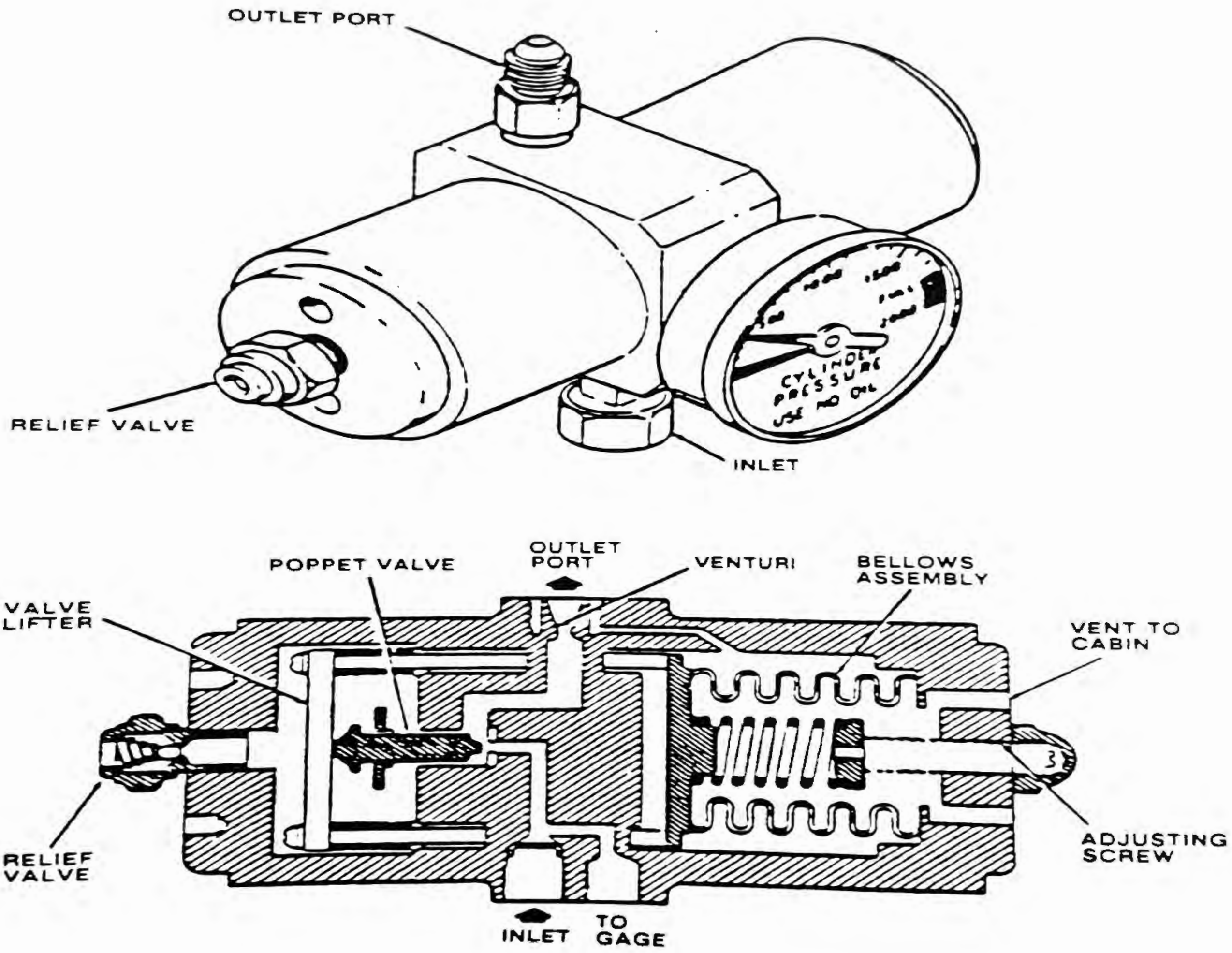
(b) A breathing tube extends from the mask housing. This tube has a disconnect plug on the end. The plug connects into the diluter-demand regulator supply line or into the portable oxygen cylinder.



CREW OXYGEN SYSTEM

FTX80707

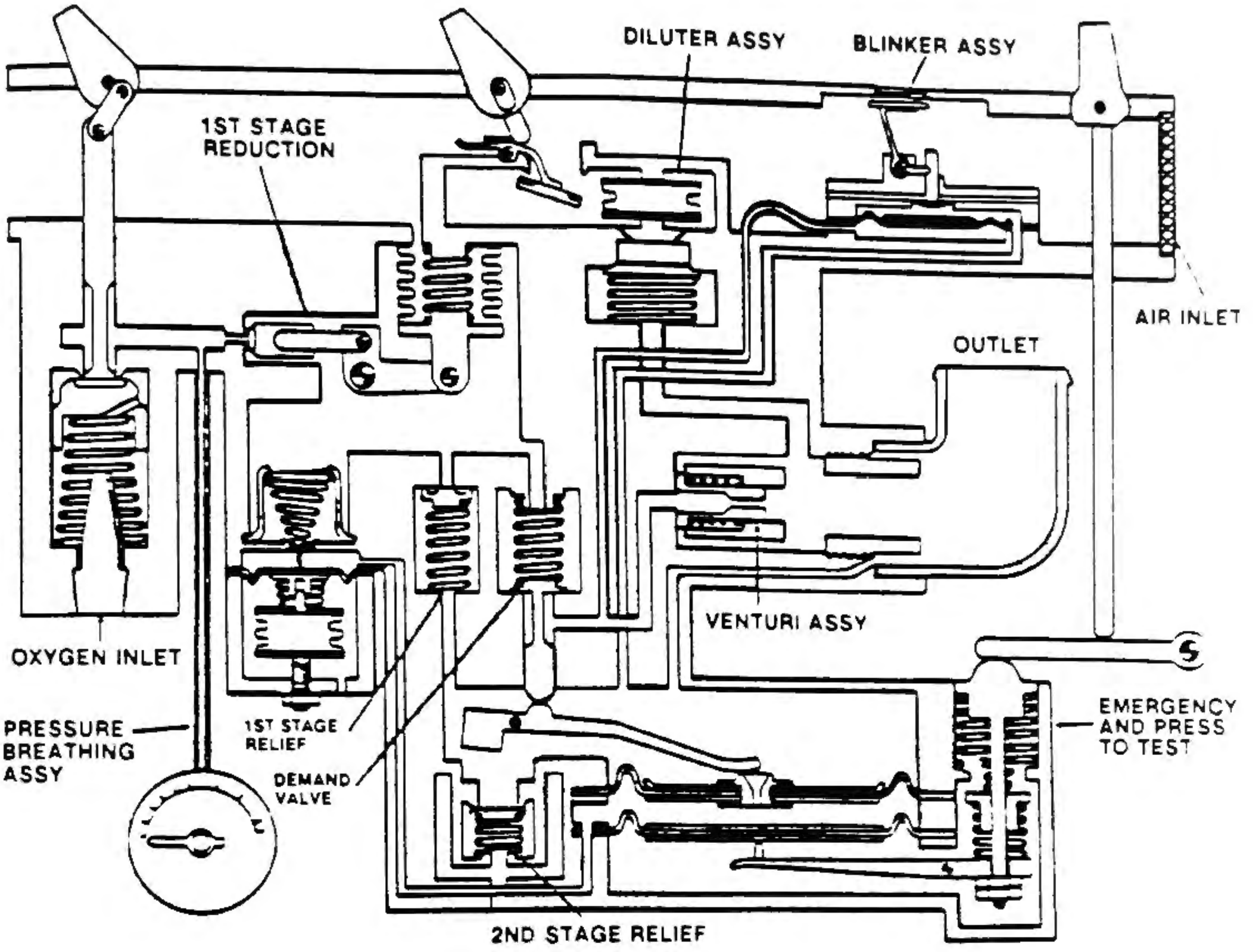
Figure 1-67



CREW OXYGEN CYLINDER REGULATOR - SCHEMATIC

Figure I-68

FTX80708



OXYGEN DILUTER - DEMAND REGULATOR
(TYPICAL) - SCHEMATIC

FTX80709

Figure 1-69

supply available. Also on the front face is a light that illuminates the entire front face of the regulator; this light is controlled by the cockpit lighting switch.

(c) On either side of the regulator are screened openings that permit the flow of ambient air into the regulator. On the back side of the regulator are the oxygen inlet and outlet lines.

(d) When the supply toggle is in the off position, a plunger and spring arrangement blocks the inlet passage. When the toggle switch is in the position, oxygen enters the regulator. Under normal operation, the selector toggle switch is in the normal position. This opens a gauge-type valve and permits ambient air within the regulator to enter the passages and mix with the pure oxygen. The amount of air permitted to mix with the oxygen is controlled by a diluter assembly, located adjacent to the gate valve. This unit contains an aneroid which reduces the amount of air to be mixed with the oxygen as the altitude is increased to approximately 30,000 feet.

(e) Oxygen entering the regulator at the inlet line first goes through a pressure reducing stage. At this point, a bellows and spring arrangement, which is vented to atmosphere on one side and chamber pressure on the other, controls the oxygen pressure. Initially, the inlet valve is held open by the spring-loaded bellows. As oxygen flows from the inlet valve, its pressure compresses the bellows and closes the inlet valve to control the chamber pressure to 30 psig.

(f) From the first stage reduction area, oxygen flows to the demand valve. When the wearer inhales through the mask, a vacuum is created on the top of two parallel diaphragms located upstream of the demand valve. Oxygen which has flowed to the demand valve and between these diaphragms forces the top diaphragm upward. A lever attached to this diaphragm pushes the demand valve open and oxygen flows through the valve to the mask. The amount of oxygen that passes through the demand valve is controlled by the pressure-breathing assembly. This assembly contains an evacuated bellows, which controls the amount of oxygen pressure directed to the double diaphragm that actuates the demand valve.

(c) A microphone and oxygen valve assembly are inside the mask housing. A microphone cable and jack assembly, which is plugged into the radio system jack located in the stowage box, extends from the microphone. The oxygen valve assembly opens and closes with the breathing of the wearer. The mask is ready for immediate use when removed from its stowage box and put on the user's face.

(d) Courier seat masks do not include a microphone.

(5) Check Valves

Check valves are installed downstream of the cabin shutoff valves to allow the flight crew to receive oxygen from both oxygen cylinders. The courier can only receive oxygen from one of the oxygen cylinders.

C. Operation

(1) Oxygen from the high-pressure oxygen cylinder flows through the system lines to the individual demand regulators. The markings on a pressure-indicating dial of each regulator indicate the available oxygen supply in the system. Three toggle valves on the regulator enable the selection of the various methods of supplying oxygen to the mask.

(2) A selector toggle on the regulator panel has normal oxygen and 100 percent oxygen positions. When this toggle is in the 100 percent position, only pure oxygen is permitted to the mask. When this toggle is in the normal oxygen position, inlet ambient air is mixed with the oxygen according to cabin altitude.

(3) The emergency toggle has emergency, normal and test mask positions. In the spring-loaded test mask position, oxygen is permitted to flow to the mask to check for proper functioning. The toggle returns to the normal or center position when released. In the emergency position, the emergency diaphragm in the regulator unit is actuated and a positive pressure is sent to the mask. (Since the demand valve in the regulator is bypassed, oxygen is sent directly to the mask, and inhalation is not required to open the demand valve.)

(4) For the system to be in operation, the on-off toggle must be in the on position. For normal operation of the system, the selector toggle should be in the normal position. This supplies oxygen to the masks

upon demand, diluting the oxygen with air as controlled by the aneroid within the regulator. Should cabin decompression occur at altitudes above 28,000 feet, a pressure-breathing assembly within the regulator automatically senses the change in cabin pressure and supplies positive pressure oxygen to the mask by bypassing the demand valve. For this normal operation, the emergency toggle must be in the normal position (center). For protective-breathing purposes (smoke in the cabin, etc.), the selector toggle must be in the 100 percent oxygen position. This closes the air valve in the regulator. permitting only pure oxygen to reach the mask.

(5) Should the regulator fail, the selector toggle must be in the 100 percent oxygen position and the emergency toggle must be in the emergency position. This feeds only pure oxygen to the masks. The emergency position of the emergency toggle mechanically actuates the emergency diaphragm in the regulator unit, supplying positive oxygen pressure to the masks.

68. Protective Breathing Equipment (PBE) - Description and Operation

A. The PBE (Protective Breathing Equipment) is designed as a self-contained unit that supplies a breathable atmosphere to protect crew members from the effects of smoke, carbon dioxide, or other harmful gases and oxygen deficiency (caused by other than an airplane depressurization). It consists of a hood, two cylinders to supply aviator grade oxygen, service/end of service indicating lights, visual service indicator, and a special mounting container.

(1) The hood is made from materials that provide protection from smoke and gases and is worn over the head. The inside of the hood has an anti-fog coating that provides adequate vision capability during normal use.

(2) The two oxygen cylinders provide aviator grade oxygen during use, and are activated by snapping open the hood and separating the two oxygen cylinders. These cylinders will provide up to 15 minutes of oxygen depending upon the individual, and workload requirements. The first cylinder releases oxygen at a faster rate to allow immediate use. To be fully operational the second oxygen bottle must release its contents and illuminate the green light. The oxygen cylinders are not considered to be field replaceable parts.

(3) The service/end-of-service indicator incorporates a battery operated indicator, located at eye level on the left side of the hood, that indicates to the crew member the operating status of the PBE. A flashing green light indicates that the PBE has been activated and is functioning properly. An alternating RED/GREEN light indicates that the useful life of the PBE has been exhausted.

(4) The mounting container is an integral part of the PBE assembly, and houses the PBE hood assembly. It is provided with a tamper proof seal or seals depending upon PBE configuration.

(5) The RED visual service indicator (VSI) is provided as a visual indication of the serviceability of the PBE unit. If the RED VSI is exposed (protruding past the face of the mounting container) this is an indication that the PBE vacuum seal is faulty and further inspection is required.

69. Smoke Detector System - Description and Operation

A. General

The Protector Smoke Detection system consists of three detectors, a common control amplifier, cockpit test switches, and an annunciator. The Smoke Detector System is installed in the aircraft to provide a warning to the flight crew indicating the presence of smoke in the cabin area.

B. Operation

(1) The Smoke Detector system is powered from the 28 VDC Left Emer. Bus. A stream of ambient air, gathered from four intake ports along the cabin side wall, is passed continuously across a photocell inside the smoke detectors. Any smoke in the stream will reflect light into the photocell. If any light is reflected into the photocell, a signal is sent to the amplifier. The amplifier, in turn, relays the signal to the cockpit to activate the smoke detector annunciator. The annunciator will remain illuminated until the smoke level drops to an acceptable level, or until the triggered detector is turned off in the cockpit.

(2) When the smoke detector is placed in the TEST mode, the TEST lamp inside the smoke detector illuminates, triggering the photocell.

C. Cockpit Controls

The operating controls for the smoke detector system are located on the flight engineer's upper right instrument panel. The controls consist of three red guarded toggle switches and the annunciator. In the normal position (red guards up i.e., closed) the smoke detectors are ON. Opening the covers allows the toggle switches to be placed to the OFF position (center position), or depressed to the TEST position (momentary).

70. Detection - Description and Operation

A. General (See Figures 1-70 and 1-71)

(1) Detection consists of two smoke detection systems for the compartment. The detection systems alert the crew with a visual warning.

(2) Each of the two smoke detection systems consists of the following components:

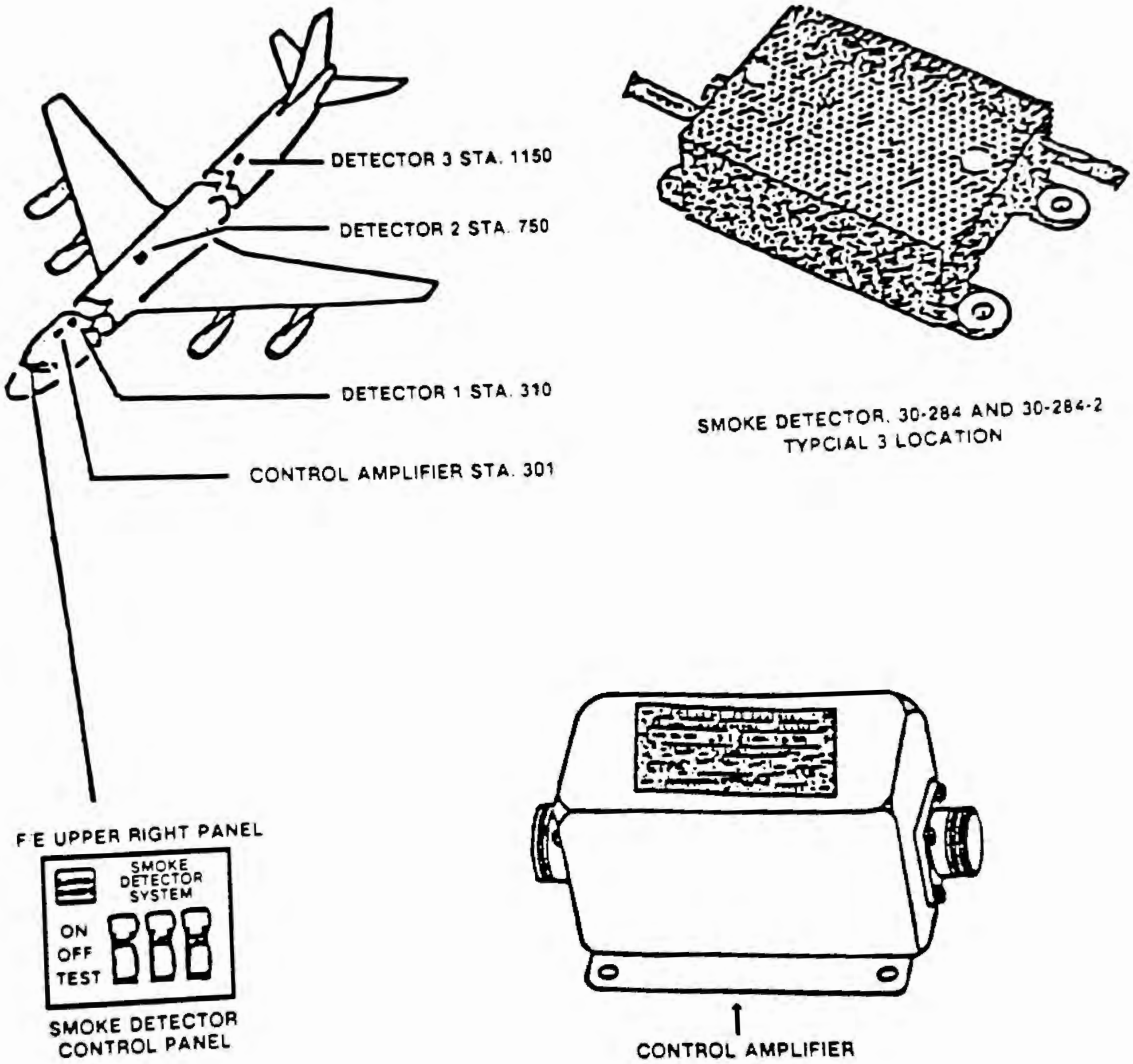
- (a) Smoke detectors
- (b) Smoke detector amplifier
- (c) Cargo smoke indicating light
- (d) Smoke detector test selector switch

B. Component Description

(1) Smoke Detectors

(a) Smoke detector units are mounted at various overhead locations in the cargo compartment and protected by a cover assembly. Each unit consists of a housing, beacon lamp, sensor, and test lamp.

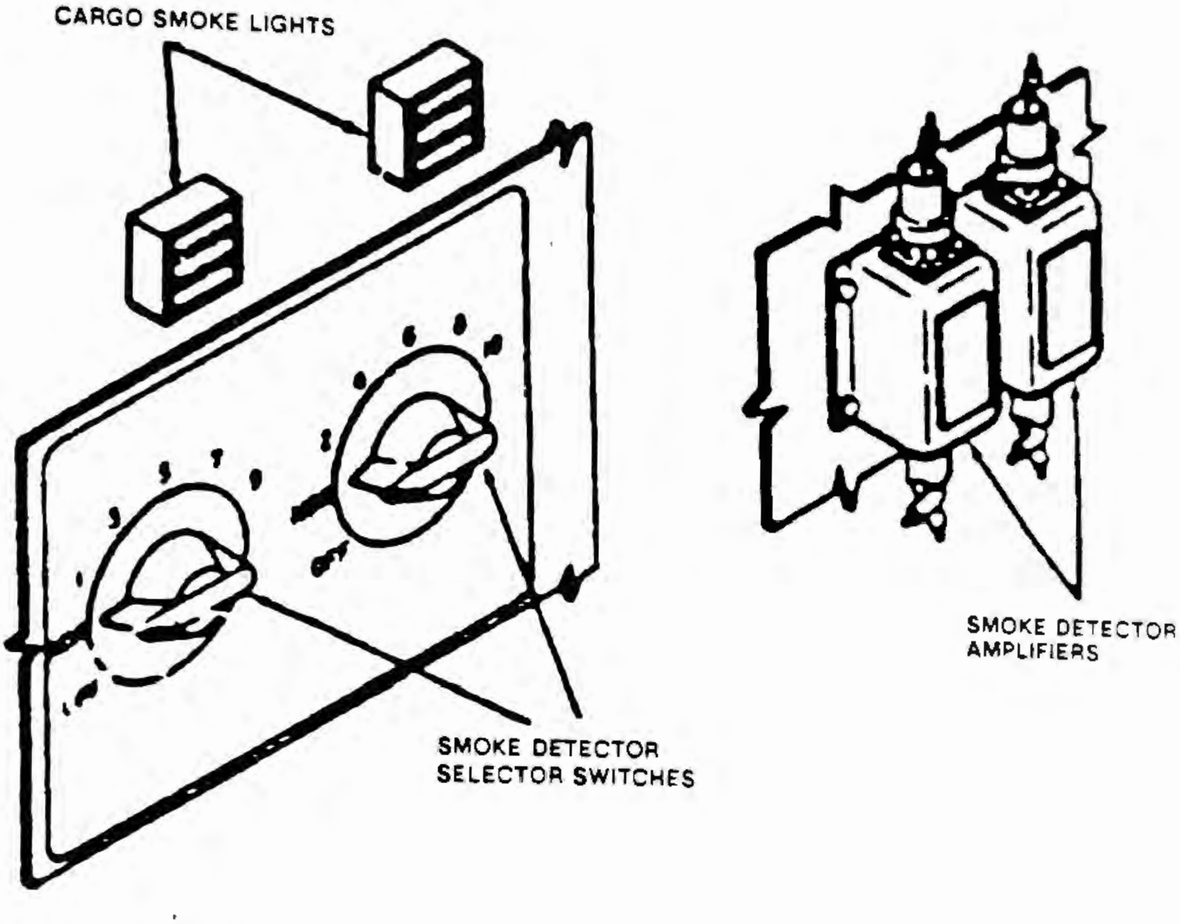
(b) The interior finish of the housing is a lusterless optical black. The beacon lamp, which is located at 90 degrees to the sensor, is on whenever the system is energized. When cabin air, which is continuously passing through the housing, reaches a predetermined smoke density, the illumination from the beacon lamp is reflected into the sensor. The sensor then transmits a signal to



SMOKE DETECTION COMPONENTS

FTX80710

Figure 1-70



FIRE DETECTION SYSTEM - COMPONENT LOCATIONS

FTX80712

Figure 1-71

the smoke detector amplifier. The test lamp is used to test the individual detector. When the test lamp is on, the light from the lamp simulates light reflected from smoke into the sensor.

(2) Smoke Detector Amplifiers

The two smoke detector amplifiers, one for each of the two smoke detection systems, are mounted on the aft center equipment panel in the electrical power center. Each smoke detector amplifier consists of a transistorized amplifier circuit and a relay. The relay is energized by the amplifier circuit when a signal is received from any one of the associated smoke detectors.

(3) Cargo Smoke Indicating Lights

The two cargo smoke indicating lights, one for each of the two smoke detection system, are located on the systems engineer's control panel. Each light is located directly above the corresponding smoke detector selector switch on the control panel. When the air passing through an odd-numbered smoke detector reaches a predetermined smoke density, the relay in the associated amplifier is energized. As a result, the cargo smoke indicating light above the odd-numbered selector, switch comes on. The smoke detector location is then isolated by rotating the switch. The system test is accomplished by rotating the selector switch and then pressing the cargo smoke indicating light as each position of the switch is selected. During the test, the light should come on when pressed and go off when released. The even-numbered smoke detection system is identical to the odd-numbered system.

(4) Smoke Detector Selector Switches

The two rotary-type smoke detector selector switches are located on the system's engineer's control panel. The odd-numbered selector switch corresponds to the odd-numbered smoke detectors and the even-numbered selector switch corresponds to even-numbered smoke detectors in the dual-smoke detection system. When the air passing through an odd-numbered smoke detector reaches the predetermined smoke density, the cargo smoke indicating light above the odd-numbered switch will come on and the detector location is then isolated by rotating the odd-numbered switch.

C. Operations

(1) Smoke Detection

(a) Operation of each of the two smoke detection systems is identical Each smoke detection system functions when the 28-VDC emergency bus is energized and the smoke detector selector switch is in the normal position. The beacon lamp is energized directly from the bus and the ground circuit is completed through the selector switch. When the air passing through the detector unit reaches a predetermined smoke density, the beacon lamp illumination is reflected in to the sensor. The sensor transits a signal to the smoke detector amplifier which amplifies the signal, actuates a relay in the amplifier, and completes a ground circuit for the cargo smoke indicating light circuit. The light comes on and remains on until smoke clears from the detector housing.

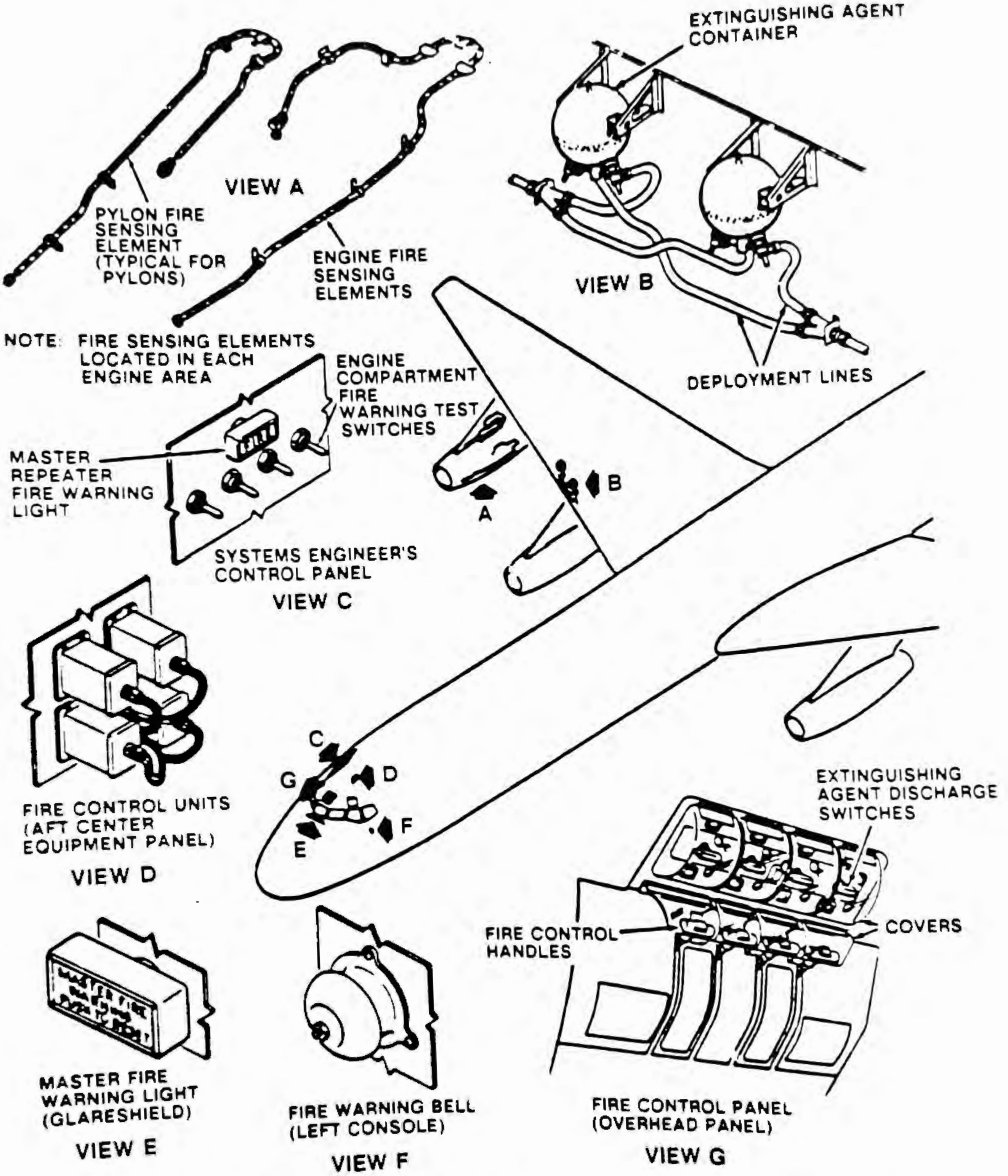
(b) The smoke detector selector switch is rotated to determine which smoke detector is transmitting the smoke density signal. The functional test operation is accomplished by rotating the selector switch and pressing the cargo indicating light as each position of the switch is selected. During the test, the light should come on when pressed and go off when released.

71. General - Description and Operation

A. Description (See Figure 1-72)

(1) Fire protection consists of a fire detection system for each engine compartment, a fixed fire extinguishing system in each wing, and portable fire extinguishers located in the flight and passenger compartments. The detection system detects a fire in an engine compartment and alerts the crew by audio and visual indications. The fixed fire extinguishing system provides the means to extinguish the fire.

(2) The fire detection system consists of sensing elements, fire control units, and audio/visual warning components. Sensing elements are located on the underside of the engine and under the pylon apron, forward and aft of the fireseal. The sensing elements are interconnected to form a continuous loop circuit in each engine compartment. Fire control units, one for each engine compartment sensing circuit,


EXTINGUISHING AGENT CONTAINER
PYLON FIRE SENSING ELEMENT (TYPICAL FOR PYLONS)
VIEW A
ENGINE FIRE SENSING ELEMENTS
VIEW B
DEPLOYMENT LINES
NOTE: FIRE SENSING ELEMENTS LOCATED IN EACH ENGINE AREA
ENGINE COMPARTMENT FIRE WARNING TEST SWITCHES
MASTER REPEATER FIRE WARNING LIGHT
SYSTEMS ENGINEER'S CONTROL PANEL
VIEW C
A
B
C
D
E
F
G
FIRE CONTROL UNITS (AFT CENTER EQUIPMENT PANEL)
VIEW D
EXTINGUISHING AGENT DISCHARGE SWITCHES
FIRE CONTROL HANDLES
COVERS
MASTER FIRE WARNING PUSH TO RESET
MASTER FIRE WARNING LIGHT (GLARESHIELD)
VIEW E
FIRE WARNING BELL (LEFT CONSOLE)
VIEW F
FIRE CONTROL PANEL (OVERHEAD PANEL)
VIEW G

FIRE DETECTION AND EXTINGUISHING SYSTEMS

FTX80901

Figure 1-72

are installed in the center aft equipment panel in the flight compartment. The units continuously monitor the sensing elements and actuate the audio/visual warning components to alert the crew if critical temperature is reached in the engine compartments. Audio/visual warning components are located in the flight compartment. Engine compartment fire warning lights are located in fire control handles adjacent to the overhead switch panel. A master fire warning light is located on the glareshield. A master repeater fire warning light and four engine compartment fire warning test switches are located on the system engineer's control panel. Audio warning is provided by a fire warning bell located in the left console.

(3) The fixed fire extinguishing system consists of a fire agent discharge control panel; four fire extinguishing agent containers (two containers located between the pylons in each wing leading edge); eight electrically fused, explosive cartridge operated, agent discharge valves (two on each container); deployment lines; and nozzles for distributing the extinguishing agent to engine compartments. Either of the two containers in each wing can be discharged into either engine compartment of the same wing, or both containers can be discharged into the same engine compartment. All containers can be discharged simultaneously for all engines emergency fire extinguishing.

(4) Portable fire extinguishers are provided to extinguish fires in the flight and passenger compartments and areas accessible from these compartments.

72. Detection - Description and Operation

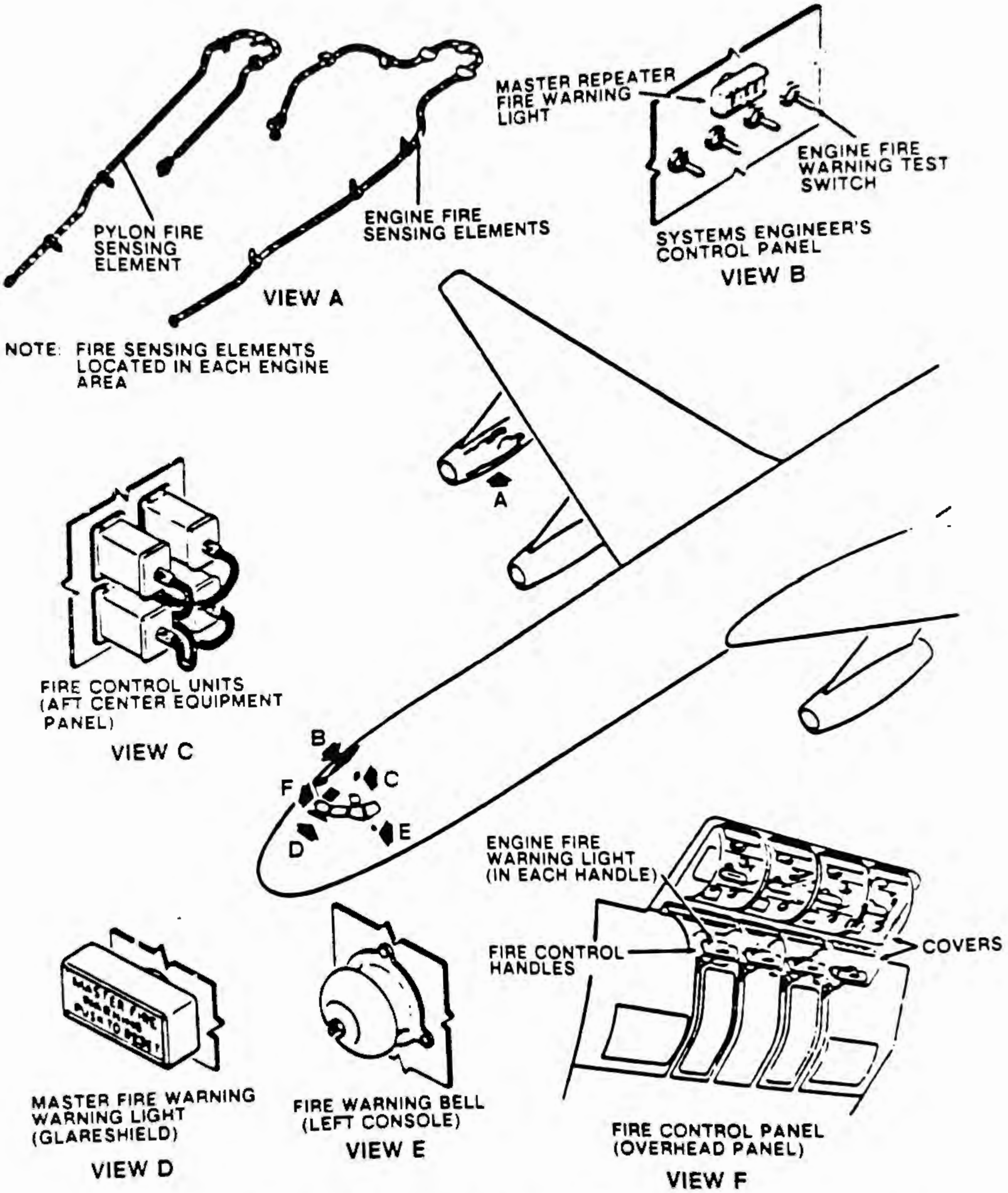
A. General

The fire detection system detects fire in the engine compartments and alerts the crew by audio/visual indications. The system consists of the following components (see Figure 1-73).

(1) Fire sensing elements

(2) Fire control units

(3) Fire warning indication components (audio/visual)


PYLON FIRE SENSING ELEMENT
ENGINE FIRE SENSING ELEMENTS
VIEW A
NOTE: FIRE SENSING ELEMENTS LOCATED IN EACH ENGINE AREA
MASTER REPEATER FIRE WARNING LIGHT
ENGINE FIRE WARNING TEST SWITCH
SYSTEMS ENGINEER'S CONTROL PANEL
VIEW B
A
FIRE CONTROL UNITS (AFT CENTER EQUIPMENT PANEL)
VIEW C
B
C
F
D
E
ENGINE FIRE WARNING LIGHT (IN EACH HANDLE)
FIRE CONTROL HANDLES
COVERS
MASTER FIRE WARNING WARNING LIGHT (GLARESHIELD)
VIEW D
FIRE WARNING BELL (LEFT CONSOLE)
VIEW E
FIRE CONTROL PANEL (OVERHEAD PANEL)
VIEW F

FIRE DETECTION SYSTEM - COMPONENT LOCATIONS

FTX80902

Figure 1-73

B. Component Description

(1) Fire Sensing Elements

(a) There are three fire sensing elements in each engine compartment. One element is located on the underside of the engine, one element is located on the underside of the pylon apron forward of the fireseal, and one element is located on the pylon apron aft of the fireseal. The three sensing elements are interconnected to form a sensing loop within the engine compartment.

(b) Each fire sensing element consists of a center conductor wire embedded coaxially within a metal tube. Densely compacted thermistor material surrounds the center conductor. The center conductor is protected by a larger perforated tube and is held concentric by spacers situated at 3-inch intervals for the entire length of sensing element. Fire detection is accomplished by monitoring the amount of capacitance and the energy available for discharge by the sensing elements as the temperature increases. When available energy is sufficient to overcome fixed gate bias voltage on a silicon control rectifier within the control unit, the silicon controlled rectifier conducts and initiates the fire warning indication sequence.

(c) Each sensing element is secured to support brackets by quick-opening clamps. Each element can be removed from the airplane as a unit. Because of physical differences in sensing element assemblies, elements can be installed only in the engine area for which they are designated.

(2) Fire Control Units

There are four 115-vac fire control units, one for each engine, located in the aft center equipment panel of the electrical power center. Each control unit can detect a fire condition in the corresponding engine compartment by sensing the amount of energy available for discharge on the sensing element. Sensing element capacitance increases with increasing temperature, thus, more of the energy entering the element during the first 1/2 cycle of the applied AC signal is retained for discharge back to the control unit during the following 1/2 cycle. When available energy is sufficient to overcome fixed bias on a silicon controlled rectifier within the unit, the silicon controlled rectifier conducts and initiates the fire warning indication components within the flight compartment. If the sensing element is shorted to ground, no energy can be retained, and no fire warning is initiated.

(3) Fire Warning Indication Components

The fire warning indication system consists of a dual red master fire warning light located on the glareshield, a dual red master repeater fire warning light located on the systems engineer's control panel, engine compartment fire warning lights located in the corresponding engine fire control handles, and a vibrator-type fire warning bell located in the left console. Components are energized when a fire condition exists or system integrity tests are performed. A fire detection system reset switch is incorporated in the master fire warning light assembly. If the fire warning indication components are energized, pressing the master fire warning light cover completes a circuit to each fire control unit reset relay. Master fire warning light and master repeater fire warning light go off, and fire warning bell stops ringing.

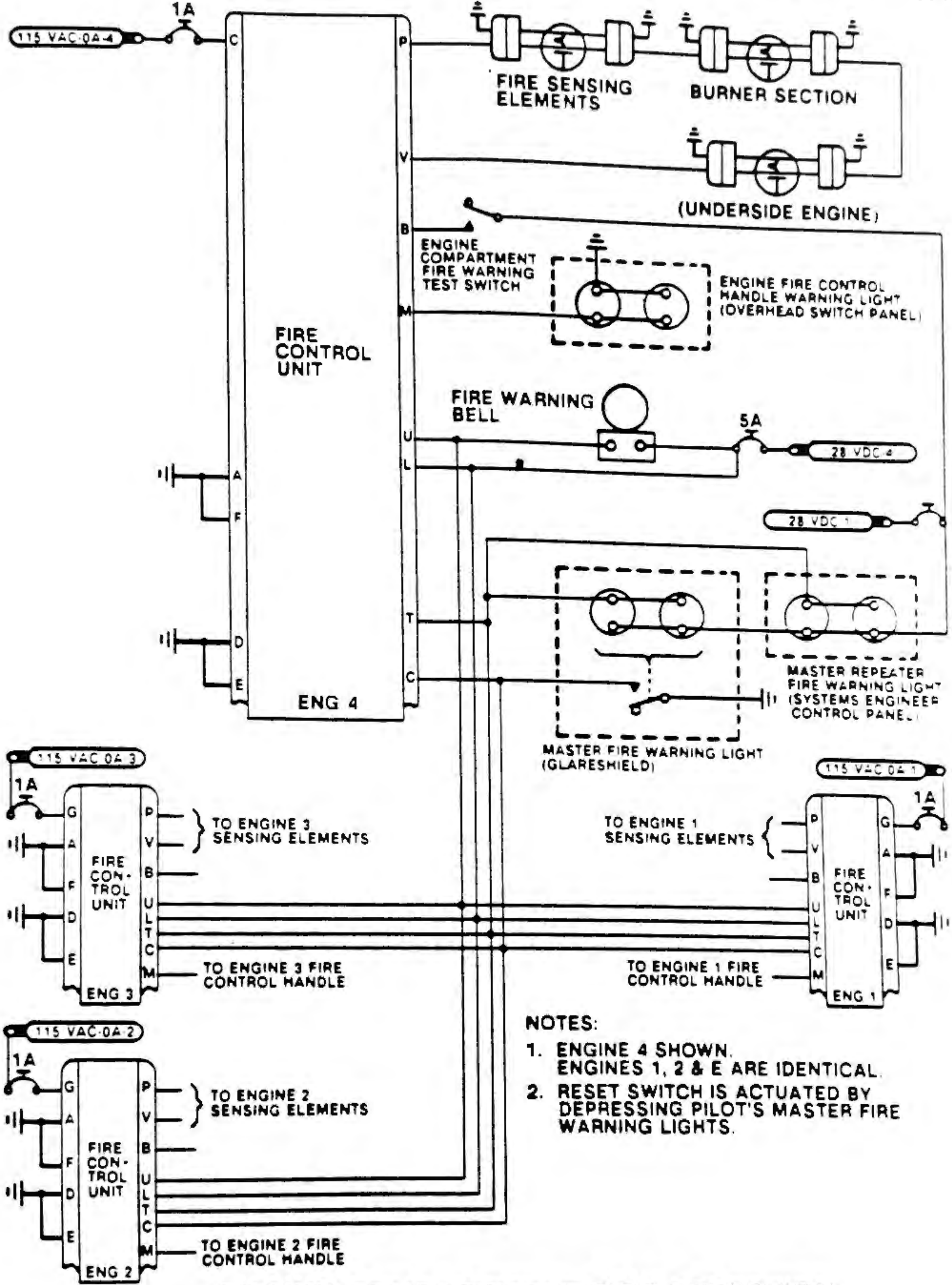
(4) Engine Compartment Fire Warning Test Switches and Indicators

There are four two-position, spring-loaded-to-normal, engine compartment fire warning test switches on the systems engineer's control panel. Fire detection system integrity tests are performed by actuating each switch to the test position. The switches are numbered 1 through 4 to correspond with engine compartments.

C. Operation

(1) Fire detection is automatic when airplane electrical buses are energized (see Figure 1-74); and when the four fire agent discharge and pressure low warning circuit breakers, located on the battery bus section of the EPC circuit breaker panel, and the four engine fire detector circuit breakers, located on the heat, vent and ice protection section of the EPC circuit breaker panel, are closed.

(2) When a fire condition exists in an engine compartment, the master fire warning light and master repeater fire warning light come on, and the fire warning bell rings. The engine compartment fire warning light in the corresponding engine fire control handle also come on.


115 VAC-0A-4
1A
C
P
V
B
M
U
L
T
C
A
F
D
E
FIRE CONTROL UNIT
ENG 4
FIRE SENSING ELEMENTS
BURNER SECTION
(UNDERSIDE ENGINE)
ENGINE COMPARTMENT FIRE WARNING TEST SWITCH
ENGINE FIRE CONTROL HANDLE WARNING LIGHT (OVERHEAD SWITCH PANEL)
FIRE WARNING BELL
5A
28 VDC-4
28 VDC-1
MASTER REPEATER FIRE WARNING LIGHT (SYSTEMS ENGINEER CONTROL PANEL)
MASTER FIRE WARNING LIGHT (GLARESHIELD)
115 VAC-0A-3
1A
G
A
F
D
E
P
V
B
U
L
T
C
M
FIRE CON-TROL UNIT
ENG 3
TO ENGINE 3 SENSING ELEMENTS
TO ENGINE 3 FIRE CONTROL HANDLE
115 VAC-0A-1
1A
TO ENGINE 1 SENSING ELEMENTS
TO ENGINE 1 FIRE CONTROL HANDLE
FIRE CON-TROL UNIT
ENG 1
115 VAC-0A-2
1A
TO ENGINE 2 SENSING ELEMENTS
TO ENGINE 2 FIRE CONTROL HANDLE
FIRE CON-TROL UNIT
ENG 2

NOTES:

1. ENGINE 4 SHOWN. ENGINES 1, 2 & E ARE IDENTICAL.
2. RESET SWITCH IS ACTUATED BY DEPRESSING PILOT'S MASTER FIRE WARNING LIGHTS.

ENGINE COMPARTMENT FIRE DETECTION SYSTEM - SCHEMATIC

FTX80903

Figure 1-74

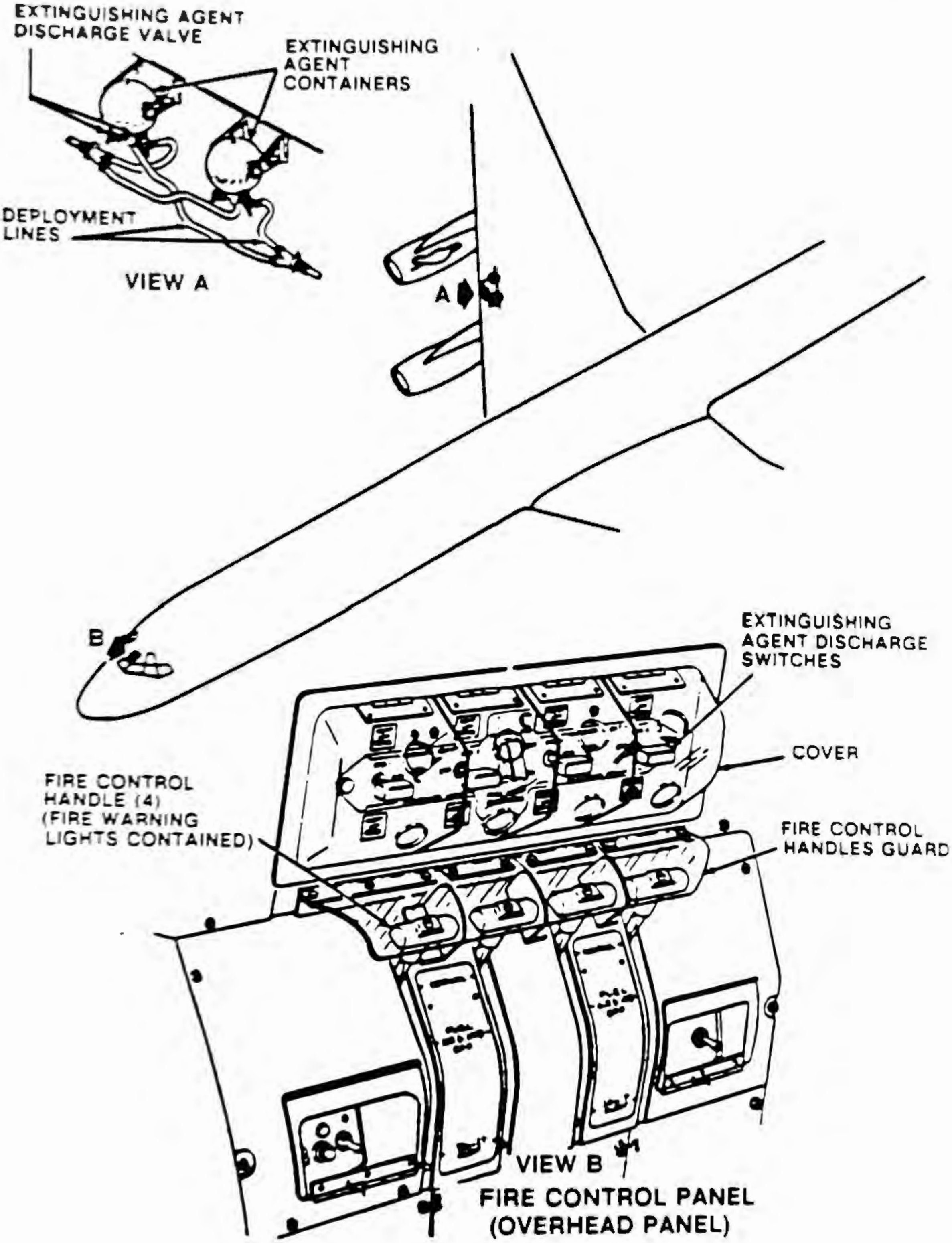
(2) When the master fire warning light cover is pressed, the fire detection system is reset, the fire warning bell stops ringing, and the master fire warning light and the master repeater fire warning light go off. The engine compartment fire warning light in the fire control handle will remain on until the signal from the engine fire detection system is interrupted.

(3) Circuit testing of the engine compartment fire detector sensing loops is accomplished by actuating the engine compartment fire warning test switches to the test position. This completes a circuit through a capacitator within the control unit which simulates a fire condition. When any test switch is held in the test position, the master fire warning light, the master repeater fire warning light, and the engine compartment fire warning light corresponding to the engine compartment fire detector system being tested come on, and the fire warning bell rings. When the test switch is released, fire warning lights go off, and the fire warning bell stops ringing. If the master fire warning light cover is pressed while the test switch is in the test position, the master fire warning light and the master repeater fire warning light go off, and the fire warning bell stops ringing. The engine compartment fire warning light in the fire control handle remains on until the test switch returns to the normal position.

73. Extinguishing - Description and Operation

A. General

The extinguishing system consists of independent left and right wing fixed fire extinguisher installations. Each wing installation includes two fire extinguishing agent containers with pressure gauges, four extinguishing agent discharge valves, and extinguishing agent deployment lines. Either container of a wing installation can be discharged into either engine compartment of the same wing. A fire extinguishing agent discharge control panel, located aft of the overhead switch panel in the flight compartment, contains eight amber agent pressure low indicating lights, four fire extinguishing agent discharge switches numbered 1 through 4 to correspond to engine compartments (see Figure 1-75). Portable fire extinguishers are furnished in the flight compartment and cabin areas.


EXTINGUISHING AGENT DISCHARGE VALVE
EXTINGUISHING AGENT CONTAINERS
DEPLOYMENT LINES
VIEW A
A
B
EXTINGUISHING AGENT DISCHARGE SWITCHES
COVER
FIRE CONTROL HANDLE (4) (FIRE WARNING LIGHTS CONTAINED)
FIRE CONTROL HANDLES GUARD
VIEW B
FIRE CONTROL PANEL (OVERHEAD PANEL)

EXTINGUISHING COMPONENTS

FTX80904

Figure 1-75

B. Description

(1) Fire Extinguishing Agent Containers (See Figure 1-75)

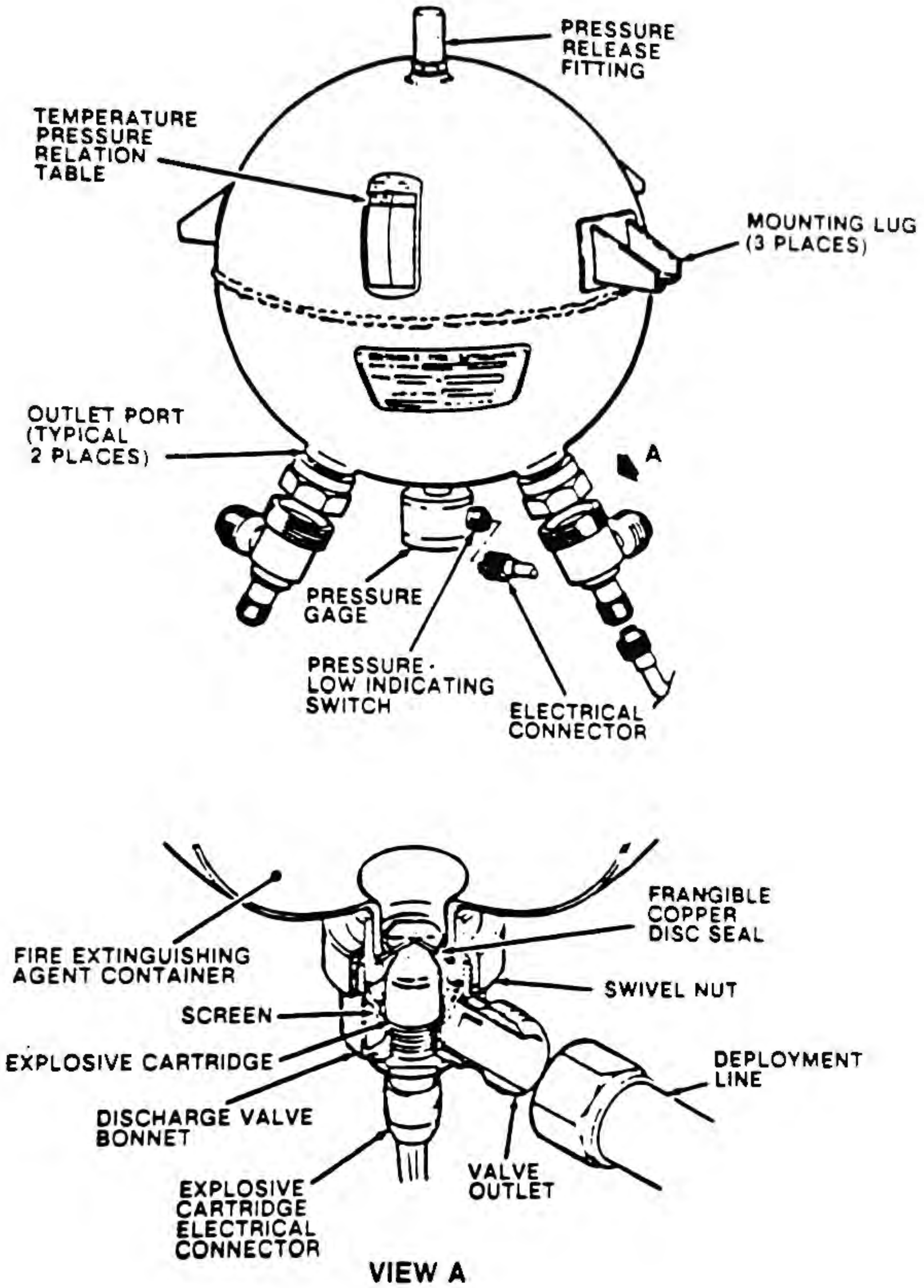
(a) The fire extinguishing agent containers store the agent until it is discharged for use. Two containers are installed on the forward side of the front spar between the engine pylons of each wing. All containers are identical and consist of spherical steel-welded units with a pressure gauge, a pressure release fitting, and two outlet ports. Each container has a minimum capacity of 378 cubic inches and is charged with 8.4 pounds of bromotrifluoromethane (CF_3BR) and sufficient gaseous nitrogen to achieve 600 psig container pressure at 70°F (21.1°C).

(b) Each container has a low-pressure indicating switch incorporated in the pressure gauge that closes and activates a low-pressure indicating light circuit when pressure in the container drops below 250 to 275 psig.

(c) The pressure release fitting on the container incorporates a seal disc that is designated to burst if the container pressure should rise to within the range of 1400 to 1790 psig. The extinguishing agent discharges through the fitting into the wing leading edge if the seal bursts. A temperature-pressure table is mounted on the container to evaluate pressure indication in relation to temperature.

(2) Discharge Valve Bonnets (See Figure 1-76)

Discharge valve bonnets are installed on each of the fire extinguishing agent container outlet ports. A swivel nut holds the valve in contact with a frangible copper disc seal. Each valve bonnet houses an explosive cartridge and a screen, and serves as an adapter for coupling the extinguishing agent container outlet port to the corresponding deployment line routed to an engine compartment.


PRESSURE RELEASE FITTING
TEMPERATURE PRESSURE RELATION TABLE
MOUNTING LUG (3 PLACES)
OUTLET PORT (TYPICAL 2 PLACES)
A
PRESSURE GAGE
PRESSURE-LOW INDICATING SWITCH
ELECTRICAL CONNECTOR
FIRE EXTINGUISHING AGENT CONTAINER
FRANGIBLE COPPER DISC SEAL
SWIVEL NUT
SCREEN
EXPLOSIVE CARTRIDGE
DEPLOYMENT LINE
DISCHARGE VALVE BONNET
VALVE OUTLET
EXPLOSIVE CARTRIDGE ELECTRICAL CONNECTOR
VIEW A

FIRE EXTINGUISHING AGENT CONTAINER

FTX80905

Figure 1-76

(3) Fire Extinguisher Explosive Cartridge (See Figure 1-76)

Fire extinguisher explosive cartridges provide the force that ruptures the frangible seal disc in the extinguishing agent containers, releasing the agent from the container and into the deployment line. The cartridge contains two squibs (powder charges) and electrical contacts. A two-pin connector on the cartridge mates to the airplane electrical system. The cartridge is fired when a circuit is completed by actuating the corresponding fire extinguishing agent discharge control panel. A slug is expelled when the squibs are fired within the explosive cartridge.

(4) Deployment Lines (See Figure 1-75)

Deployment lines are interconnected between the fire extinguishing agent containers and the engine compartments. When a fire extinguishing agent container is discharged, the extinguishing agent flows through the deployment lines to the selected engine compartment.

(5) Engine Fire Control Handles (See Figure 1-75)

There are four engine fire control handles, one for each engine, located aft of the overhead switch panel in the flight compartment. The handle knobs have a metal base and contain dual light assemblies. The assemblies red plastic covers are numbered 1 through 4 to correspond to the engine compartments. For a detailed description and operation of the fire control handles see Chapter 76.

(6) Fire Extinguishing Agent Discharge Control Panel (See Figure 1-76)

(a) The fire extinguishing agent discharge control panel is located aft of the overhead switch panel in the flight compartment and is guarded by clear plastic covers. The panel contains four extinguishing agent discharge switches, one guarded all-engines extinguishing agent discharge control switch, and eight press-to-test extinguishing agent pressure low indicating lights.

(b) Switch numbers correspond to engine compartments. When switches are positioned aft, the corresponding inboard fire extinguishing agent container is discharged. When the switch is positioned forward, the outboard container of the same wing fire extinguishing system is discharged. The extinguishing agent pressure low indicating light ground circuit are completed through the corresponding agent container explosive cartridge squibs. Integrity of the press-to-test light and agent discharge circuits can be checked without firing the explosive cartridges in the fire extinguishing agent containers.

C. Operation (See Figure 1-76)

Fire extinguishing agent discharge in an engine compartment is initiated by moving the fire control handle to the select agent position which opens the corresponding agent discharge control switch cover. The agent discharge control switches can be moved to either the inboard or outboard agent container discharge position. If emergency all-engine extinguishing is desired, the all-engines discharge switch guard is lifted, and the switch is moved to the discharge position. Electrically fused squibs, contained in the extinguishing agent discharge valve explosive cartridge, fire a slug through a frangible seal disc in the extinguishing agent container discharge port. The extinguishing agent flows under pressure through deployment lines to the engine compartment distribution nozzles.

1. General - Description and Operation

A. Description - 61 Series

(1) Fire protection consists of a fire detection system for each engine compartment, a fixed fire extinguishing system in each wing, and portable fire extinguishers located in the flight and passenger compartments. the detection system provides the means to detect a fire in an engine compartment and alert the crew by audio and visual indications. The fixed fire extinguishing system provides the means to extinguish the fire.

(2) The fire detection system consists of sensing elements, fire detector amplifiers, and audio/visual warning components. Sensing elements are located on the underside of the engine and under the pylon apron, forward and aft of the fireseal. The sensing elements are interconnected to form a continuous loop circuit in each engine compartment. Fire detector amplifier units, one for each engine compartment sensing circuit, are installed in the center aft equipment panel in the flight compartment. The units amplify the signal from the sensing elements and actuate the audio/visual warning components to alert the crew if critical temperature is reached in the engine compartments. Audio/visual warning components are located in the flight compartment. Engine compartment fire warning lights are located in the fire control handles adjacent to the overhead switch panel. A master fire warning light is located on the glareshield. A master repeater fire warning light, and four fire detector test switches are located on the systems engineer's control panel. Audio warning is provided by a fire warning bell located in the left console.

(3) The fixed fire extinguishing system consists of a fire agent discharge control panel; four fire extinguishing agent containers (two containers located between the pylons in each wing leading edge); eight electrically fused, explosive cartridge operated, agent discharge valves (two on each container); deployment lines, and nozzles for distributing the extinguishing agent to engine compartments. Either of the two containers in each wing can be discharged into either engine compartment of the same wing, or both containers can be discharged into the same engine compartment.

(4) Portable fire extinguishers are provided to extinguish fires in the flight and passenger compartments and areas accessible from these compartments.

2. Detection - Description and Operation

A. General

The fire detection system detects fire in the engine compartment and alerts the crew by audio/visual indications. The system consists of the following components (see Figure 1-77).

(1) Fire sensing elements

(2) Fire detector amplifiers

(3) Fire warning indication components (audio/visual)

B. Component Description

(1) Fire Sensing Elements

(a) There are three fire sensing elements in each engine compartment. One element is located on the underside of the engine, one element is located on the pylon apron aft of the fireseal. The three sensing elements are interconnected to form a sensing loop within the engine compartment.

(b) Each fire sensing element consists of a center conductor wire embedded coaxially within a metal tube. Densely compacted thermistor material surrounds the center conductor. Fire detection is accomplished by monitoring the resistance of the sensing elements, as measured from the center conductor to the outside grounded tube. Resistance decreases as temperature increases. A fire condition causes the sensing element resistance to reach a predetermined value, initiating the fire warning indication sequence.

(c) Each fire sensing element is held in place by a hanger, secured to support brackets by quick-opening clamps. Each hangar and attached element can be removed from the airplane as a unit. Because of differences in temperature between the engine combell stops ringing. The engine compartment fire warning light in the fire control handle remains on until the test switch returns to the normal position.

3. Extinguishing - Description and Operation

A. General

The extinguishing system consists of independent left and right wing fixed fire extinguisher installations. Each wing installation includes two fire extinguishing agent containers with pressure gauges, four extinguishing agent discharge valves, and extinguishing agent deployment lines. Either container of a wing installation can be discharged into either engine compartment of the same wing. A fire extinguishing agent discharge control panel, located aft of the overhead switch panel in the flight compartment, contains eight amber agent low-pressure indicating lights and four fire extinguishing agent discharge switches numbered 1 through 4 to correspond with engine compartments (see Figure 1-80). Portable fire extinguishers are installed in the flight and passenger compartments.

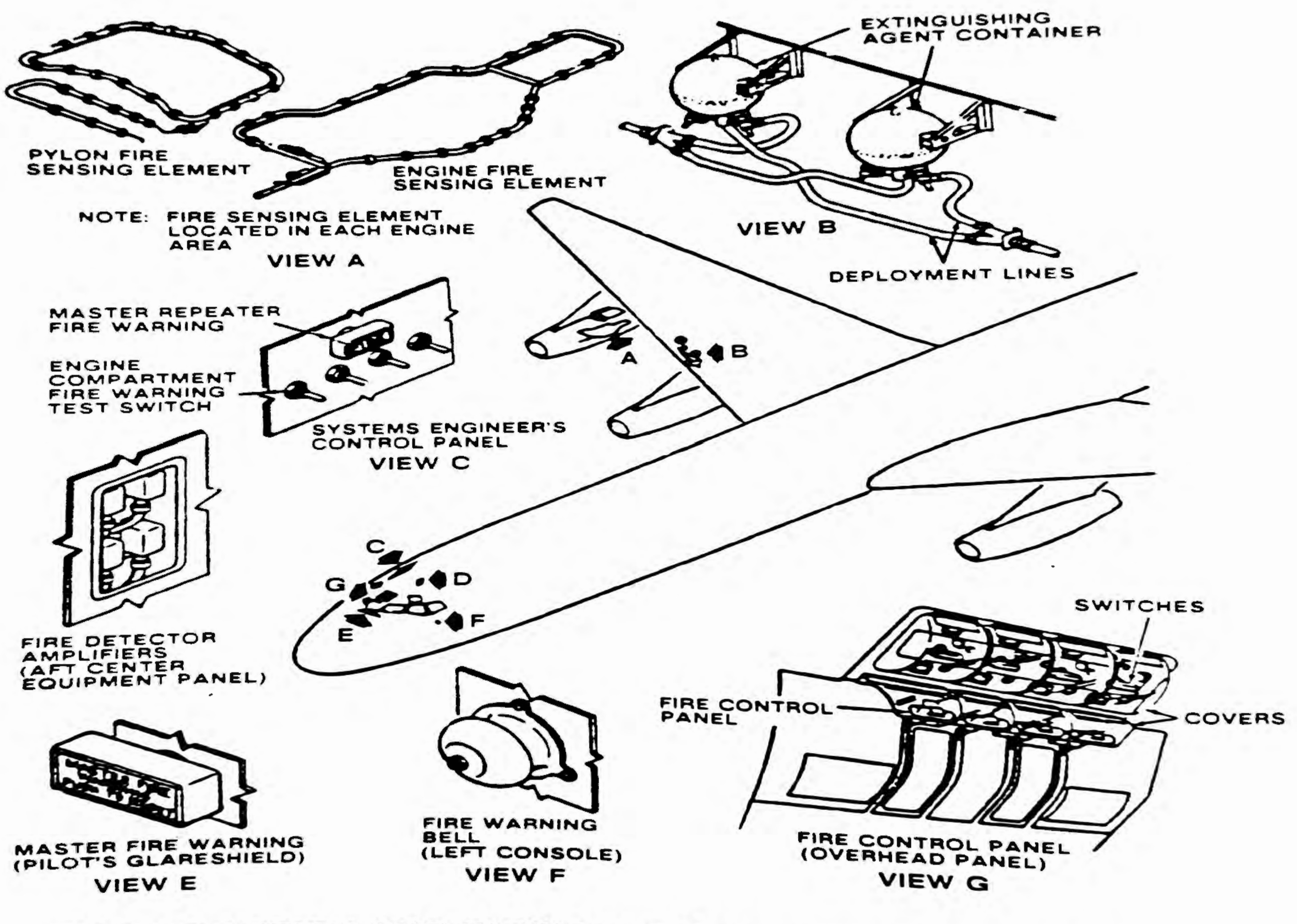
B. Description

(1) Fire Extinguishing Agent Containers (See Figure 1-81)

(a) The fire extinguishing agent containers store the agent until it is discharged for use. Two containers are installed on the forward side of the front spar between the engine pylons of each wing. All containers are identical and consist of spherical steel-welded units with a pressure gauge, a pressure release fitting, and two outlet ports. Each container has a minimum capacity of 378 cubic inches and is charged with 8.4 pounds of bromotriflouromethane (CF_3BR) and sufficient gaseous nitrogen to achieve 600-psig container pressure at 70°F (21.1°C).

(b) Each container has a low-pressure indicating switch incorporated in the pressure gauge that closes and activates a low-pressure indicating light circuit when pressure in the container drops below 250 to 275 psig.

(c) The pressure release fitting on the container incorporates a seal disc that is designed to burst if the container pressure should rise to within the range of 1400 to 1790 psig. the extinguishing agent


EXTINGUISHING AGENT CONTAINER
PYLON FIRE SENSING ELEMENT
ENGINE FIRE SENSING ELEMENT
NOTE: FIRE SENSING ELEMENT LOCATED IN EACH ENGINE AREA
VIEW A
VIEW B
DEPLOYMENT LINES
MASTER REPEATER FIRE WARNING
ENGINE COMPARTMENT FIRE WARNING TEST SWITCH
SYSTEMS ENGINEER'S CONTROL PANEL
VIEW C
A
B
C
D
G
E
F
FIRE DETECTOR AMPLIFIERS (AFT CENTER EQUIPMENT PANEL)
SWITCHES
FIRE CONTROL PANEL
COVERS
MASTER FIRE WARNING (PILOT'S GLARESHIELD)
VIEW E
FIRE WARNING BELL (LEFT CONSOLE)
VIEW F
FIRE CONTROL PANEL (OVERHEAD PANEL)
VIEW G

FIRE DETECTION AND EXTINGUISHING SYSTEMS COMPONENTS

Figure 1-77

FTX80907

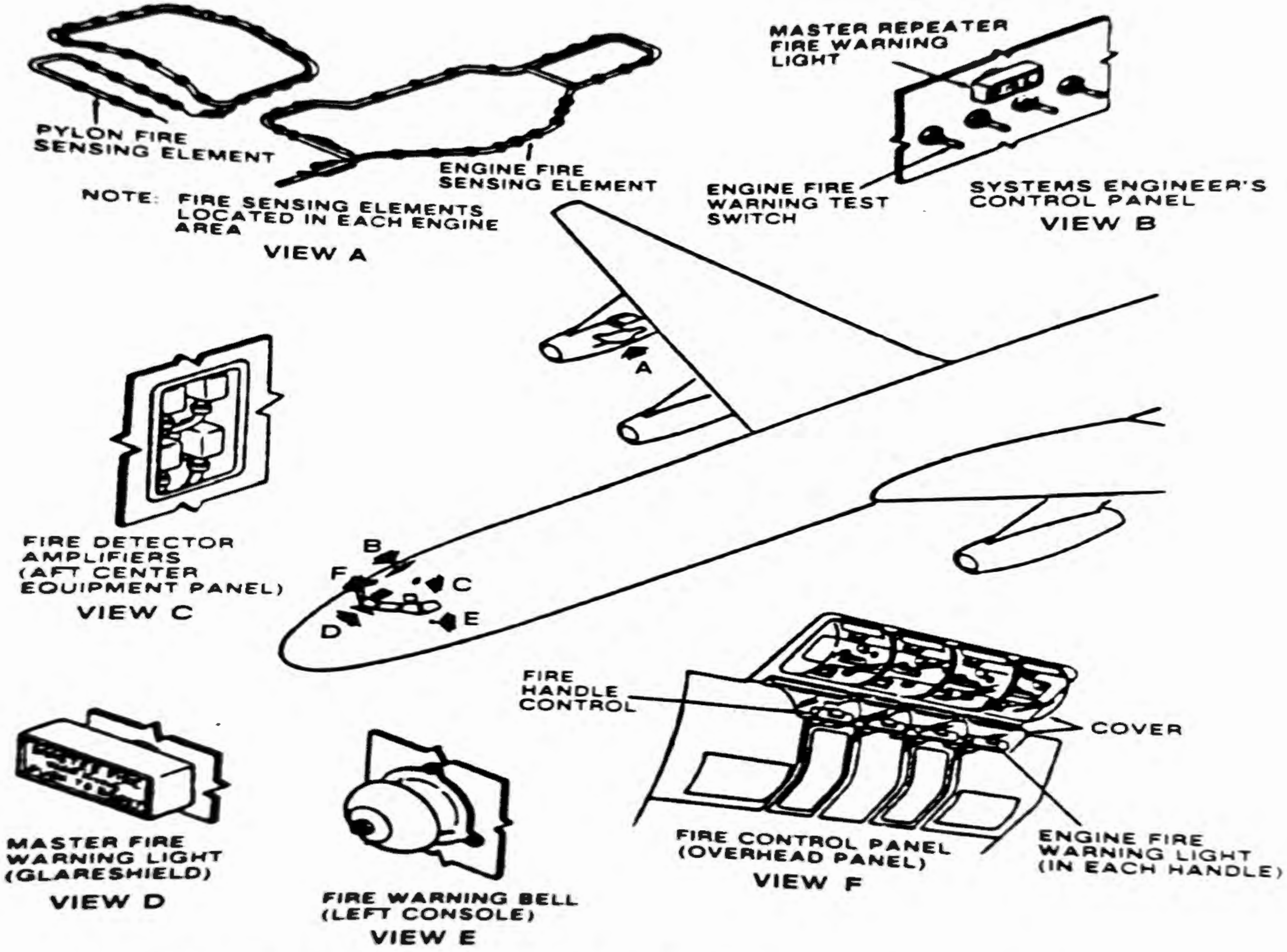
partment accessories section and burner section, elements of different temperature characteristics are used. Elements can be installed only in the engine area for which they are designated.

(2) Fire Detector Amplifiers

There are four 115-vac fire detector amplifiers, one for each engine compartment, located in the aft center equipment panel of the electrical power center (see Figure 1-78). Each amplifier can discriminate between a fire and a sensing element shorted to ground condition in the corresponding engine compartment. A ground fault reduces the sensing element resistance rapidly; a fire condition reduces the resistance more gradually. The ability to discriminate is accomplished by a shorted condition detector circuit and a fire condition detector circuit in the amplifier unit. In addition, the two detector circuits are time phased and can sense differences between fire sensing element resistance decay rates as a result of a fire or a grounded element condition. Sensing element resistance must dwell between 200 and 123 ohms for approximately 10 milliseconds to qualify as a fire condition. If element resistance drops below 123 ohms within the specified time, the short relay is actuated and no fire warning is initiated.

(3) Fire Warning Indication Components

Fire warning indication components consist of a dual red master fire warning light located on the glareshield, a dual red master repeater fire warning light located on the system's engineer's control panel, engine compartment fire warning lights located in the corresponding engine fire control handle, and a vibrator-type fire warning bell located in the left console. Components are energized when a fire condition exists or system integrity tests are performed. A fire detection system reset switch is incorporated in the master fire warning light assembly. If the fire warning indication components are energized, depressing the master fire warning light cover completes a circuit to each fire detector amplifier reset relay. The master fire warning light and master repeater fire warning light go off, and the fire warning bell stops ringing.


PYLON FIRE SENSING ELEMENT
ENGINE FIRE SENSING ELEMENT
NOTE: FIRE SENSING ELEMENTS LOCATED IN EACH ENGINE AREA
VIEW A
MASTER REPEATER FIRE WARNING LIGHT
ENGINE FIRE WARNING TEST SWITCH
SYSTEMS ENGINEER'S CONTROL PANEL
VIEW B
A
B
C
D
E
F
FIRE DETECTOR AMPLIFIERS (AFT CENTER EQUIPMENT PANEL)
VIEW C
FIRE HANDLE CONTROL
COVER
MASTER FIRE WARNING LIGHT (GLARESHIELD)
VIEW D
FIRE WARNING BELL (LEFT CONSOLE)
VIEW E
FIRE CONTROL PANEL (OVERHEAD PANEL)
VIEW F
ENGINE FIRE WARNING LIGHT (IN EACH HANDLE)

FIRE DETECTION SYSTEM - COMPONENT LOCATIONS

Figure 1-78

FTX80908

(4) Engine Compartment Fire Warning Test Switches and Indicators

There are four two-position, spring-loaded-to-normal, engine compartment fire warning test switches located on the system engineer's control panel. Fire detection system integrity tests are performed by actuating each switch to the test position. The switches are numbers 1 through 4 to correspond with engine compartments.

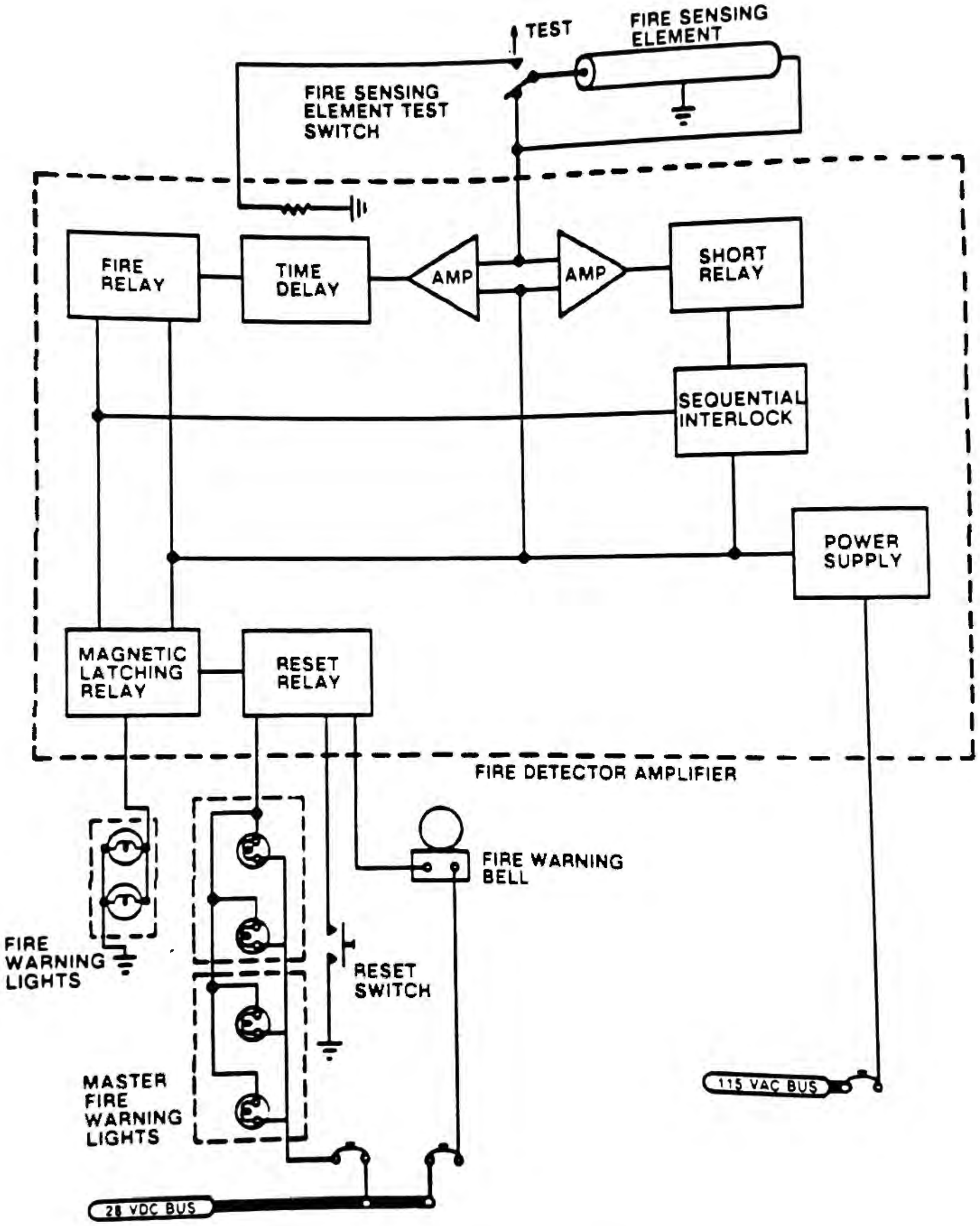
C. Operation

(1) Fire detection is automatic when airplane electrical buses are energized (see Figure 1-79); and when the four fire agent discharge and low-pressure warning circuit breakers, located on the battery bus section of the EPC circuit breaker panel, and the four engine detector circuit breakers, located on the heat, vent and ice protection section of the EPC circuit breaker panel, are closed.

(2) When a fire condition exists in an engine compartment, the master fire warning light and master repeater fire warning light come on, and the fire warning bell rings. The engine compartment fire warning light in the corresponding engine fire control handle also comes on.

(3) When the master fire warning light cover is pressed, the fire detection system is reset, the fire warning bell stops ringing, and the master fire warning light and master repeater fire warning lights go off. The engine compartment fire warning light in the fire control handle remains on until the signal from the engine fire detection system is interrupted.

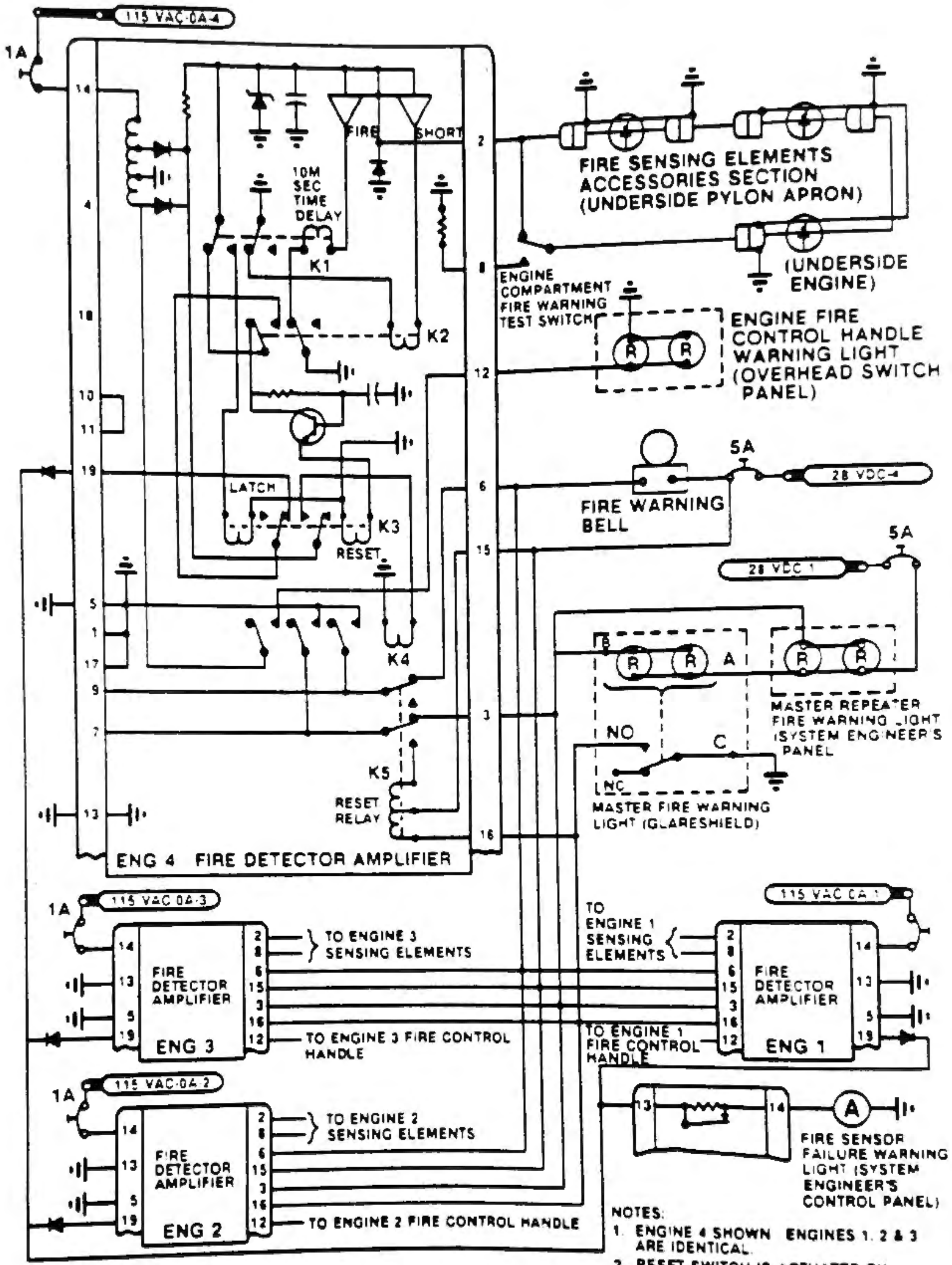
(4) Circuit testing of the engine compartment fire detector sensing loops is accomplished by actuating the fire warning test switches to the test position. This completes a circuit through a resistor within the detector amplifier, thus simulating a fire condition. When any test switch is held in the test position, the master fire warning light, the master repeater fire warning light, and the engine compartment fire warning light corresponding to the engine compartment fire detection system being tested come on, and the fire warning bell rings. When the test switch is released, fire warning lights go off, and the fire warning bell stops ringing. If the master fire warning light cover is depressed while the test switch is in the test position, the master fire warning light, and the master repeater fire warning light go off, and the fire warning



FIRE DETECTION SYSTEM - BLOCK DIAGRAM

FTX80909

Figure 1-79

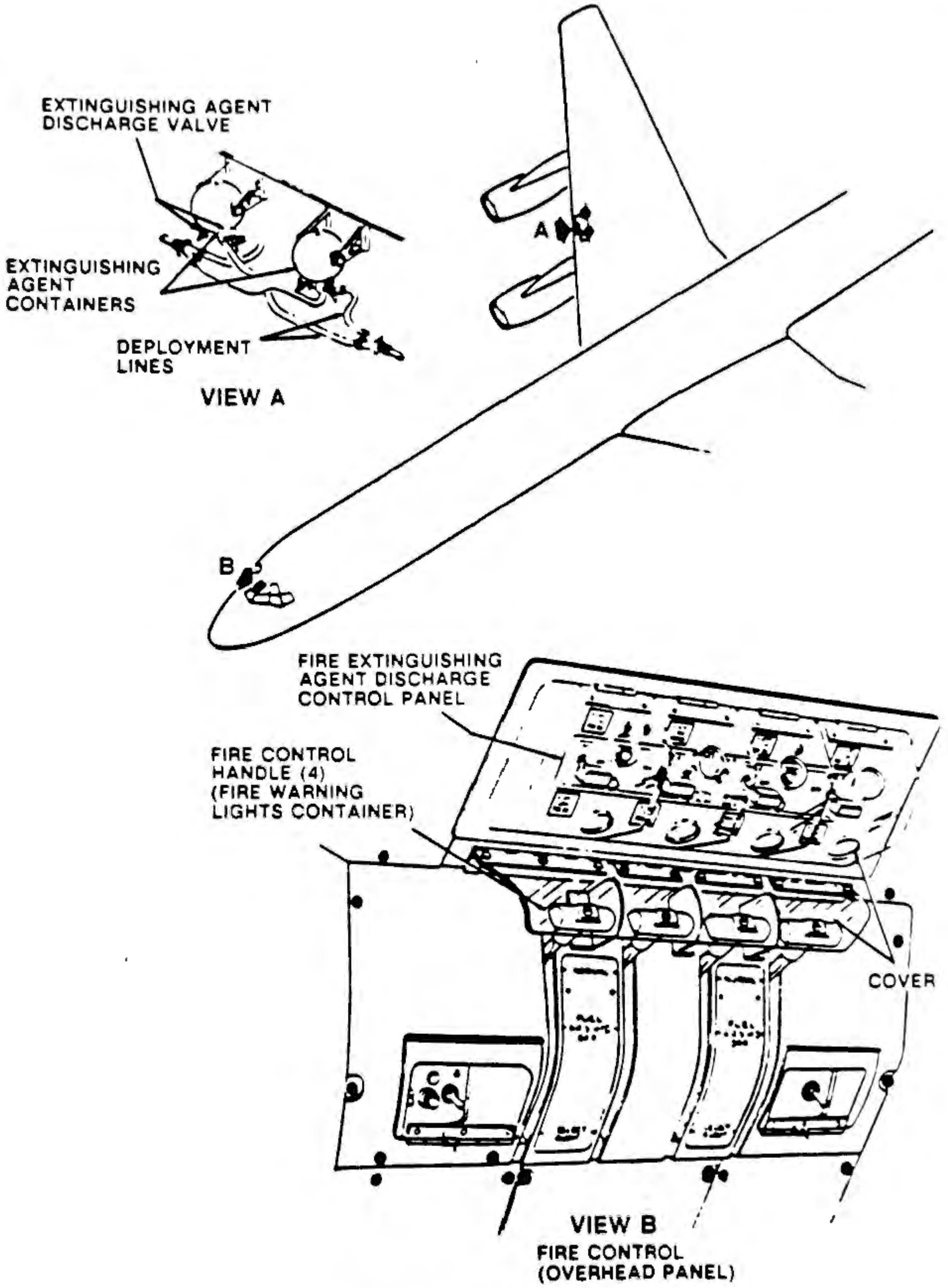

115 VAC-0A-4
1A
14
4
18
10
11
19
5
1
17
9
7
13
2
8
12
6
15
3
16
FIRE
SHORT
10M SEC TIME DELAY
K1
K2
K3
K4
K5
LATCH
RESET
RESET RELAY
ENG 4 FIRE DETECTOR AMPLIFIER
FIRE SENSING ELEMENTS ACCESSORIES SECTION (UNDERSIDE PYLON APRON)
(UNDERSIDE ENGINE)
ENGINE COMPARTMENT FIRE WARNING TEST SWITCH
R
ENGINE FIRE CONTROL HANDLE WARNING LIGHT (OVERHEAD SWITCH PANEL)
5A
28 VDC-4
FIRE WARNING BELL
28 VDC-1
B
A
NO
C
NC
MASTER FIRE WARNING LIGHT (GLARESHIELD)
MASTER REPEATER FIRE WARNING LIGHT (SYSTEM ENGINEER'S PANEL)
115 VAC-0A-3
FIRE DETECTOR AMPLIFIER
ENG 3
TO ENGINE 3 SENSING ELEMENTS
TO ENGINE 3 FIRE CONTROL HANDLE
115 VAC-0A-1
TO ENGINE 1 SENSING ELEMENTS
TO ENGINE 1 FIRE CONTROL HANDLE
ENG 1
115 VAC-0A-2
TO ENGINE 2 SENSING ELEMENTS
TO ENGINE 2 FIRE CONTROL HANDLE
ENG 2
A
FIRE SENSOR FAILURE WARNING LIGHT (SYSTEM ENGINEER'S CONTROL PANEL)

NOTES:
1. ENGINE 4 SHOWN. ENGINES 1, 2 & 3 ARE IDENTICAL.
2. RESET SWITCH IS ACTUATED BY DEPRESSING PILOT'S MASTER FIRE WARNING LIGHTS

ENGINE COMPARTMENT FIRE DETECTION SYSTEM - SCHEMATIC

FTX80910

Figure 1-80


EXTINGUISHING AGENT DISCHARGE VALVE
EXTINGUISHING AGENT CONTAINERS
DEPLOYMENT LINES
VIEW A
A
B
FIRE EXTINGUISHING AGENT DISCHARGE CONTROL PANEL
FIRE CONTROL HANDLE (4) (FIRE WARNING LIGHTS CONTAINER)
COVER
VIEW B
FIRE CONTROL (OVERHEAD PANEL)

EXTINGUISHING COMPONENTS

FTX80911

Figure 1-81

will discharge through the fitting into the wing leading edge if the seal bursts. A temperature-pressure table is mounted on the container to evaluate pressure indication in relation to temperature.

(2) Discharge Valve Bonnets (See Figure 1-82)

Discharge valve bonnets are installed on each of the fire extinguishing agent container outlet ports. A swivel nut holds the valve in contact with a frangible copper disc seal. Each valve bonnet houses an explosive cartridge and a screen and serves an an adapter for coupling the extinguishing agent container outlet port to the corresponding deployment line routed to an engine compartment.

(3) Fire Extinguisher Explosive Cartridge (See Figure 1-82)

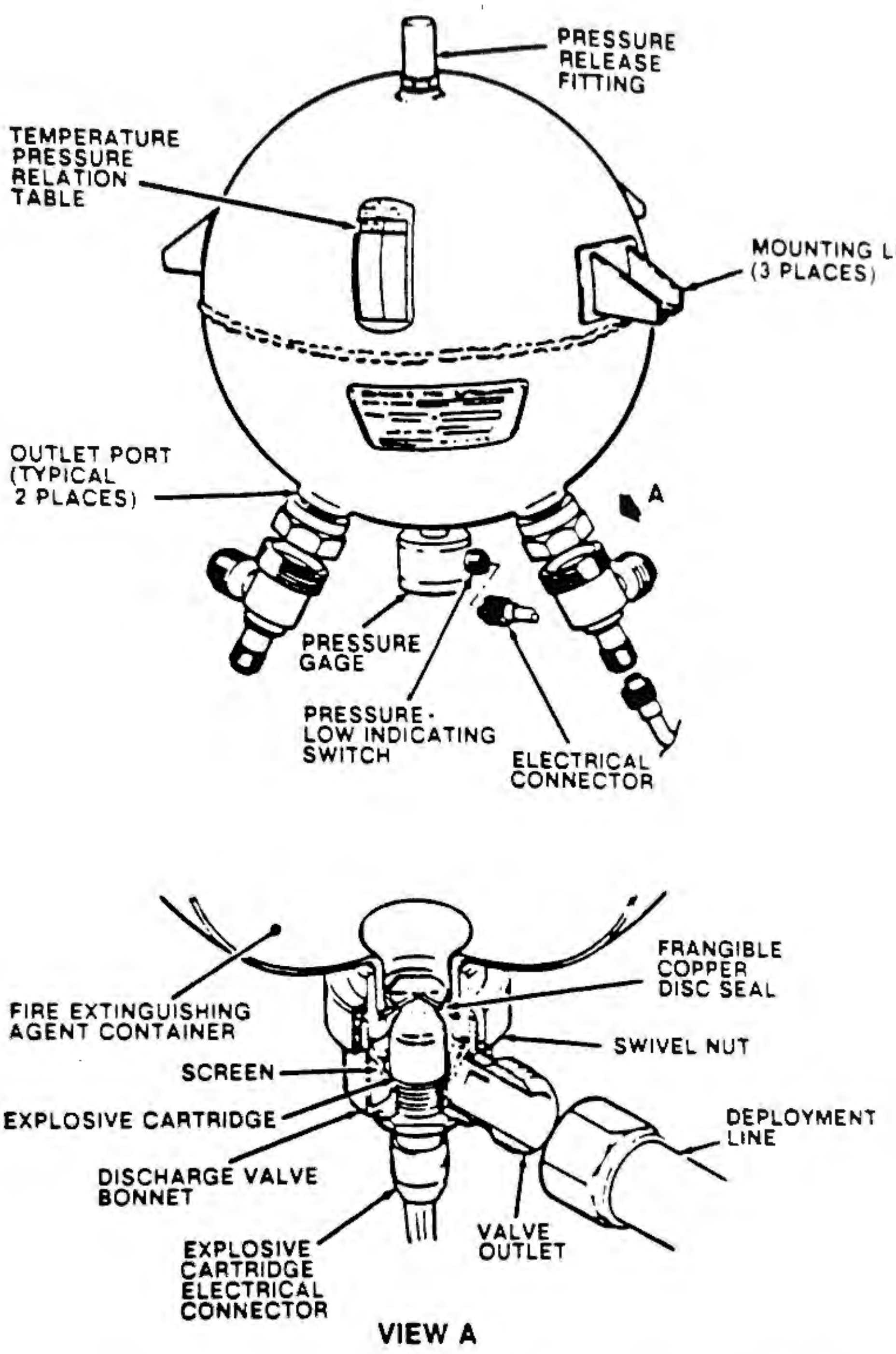
Fire extinguisher explosive cartridges provide the force that ruptures the frangible seal disc in the fire extinguishing agent containers. releasing the agent from the container and into the deployment line. The cartridge contains two squibs (powder charges) and electrical contacts. A two-pin connector on the cartridge mates to the airplane electrical system. The cartridge is fired when a circuit is completed by actuating the corresponding fire extinguishing agent discharge switch. located on the fire extinguishing agent discharge control panel. A slug is expelled when the squibs are fired within the explosive cartridge.

(4) Deployment Lines (See Figure 1-82)

Deployment lines are interconnected between the fire extinguishing agent containers and the engine compartments. When a fire extinguishing agent container is discharged, the extinguishing agent flows through the deployment lines to the selected engine compartment.

(5) Engine Fire Control Handles (See Figure 1-81)

There are four engine fire control handles, one for each engine, located aft of the overhead switch panel in the flight compartment. The handle knobs have a metal base and contain dual light assemblies. The assemblies have red plastic covers numbered 1 through 4 to correspond to the engine compartments. For a detailed description and operation of the fire control handles see Chapter 76.


PRESSURE RELEASE FITTING
TEMPERATURE PRESSURE RELATION TABLE
MOUNTING LUG (3 PLACES)
OUTLET PORT (TYPICAL 2 PLACES)
A
PRESSURE GAGE
PRESSURE-LOW INDICATING SWITCH
ELECTRICAL CONNECTOR
FRANGIBLE COPPER DISC SEAL
FIRE EXTINGUISHING AGENT CONTAINER
SWIVEL NUT
SCREEN
EXPLOSIVE CARTRIDGE
DEPLOYMENT LINE
DISCHARGE VALVE BONNET
EXPLOSIVE CARTRIDGE ELECTRICAL CONNECTOR
VALVE OUTLET
VIEW A

FIRE EXTINGUISHING AGENT CONTAINER

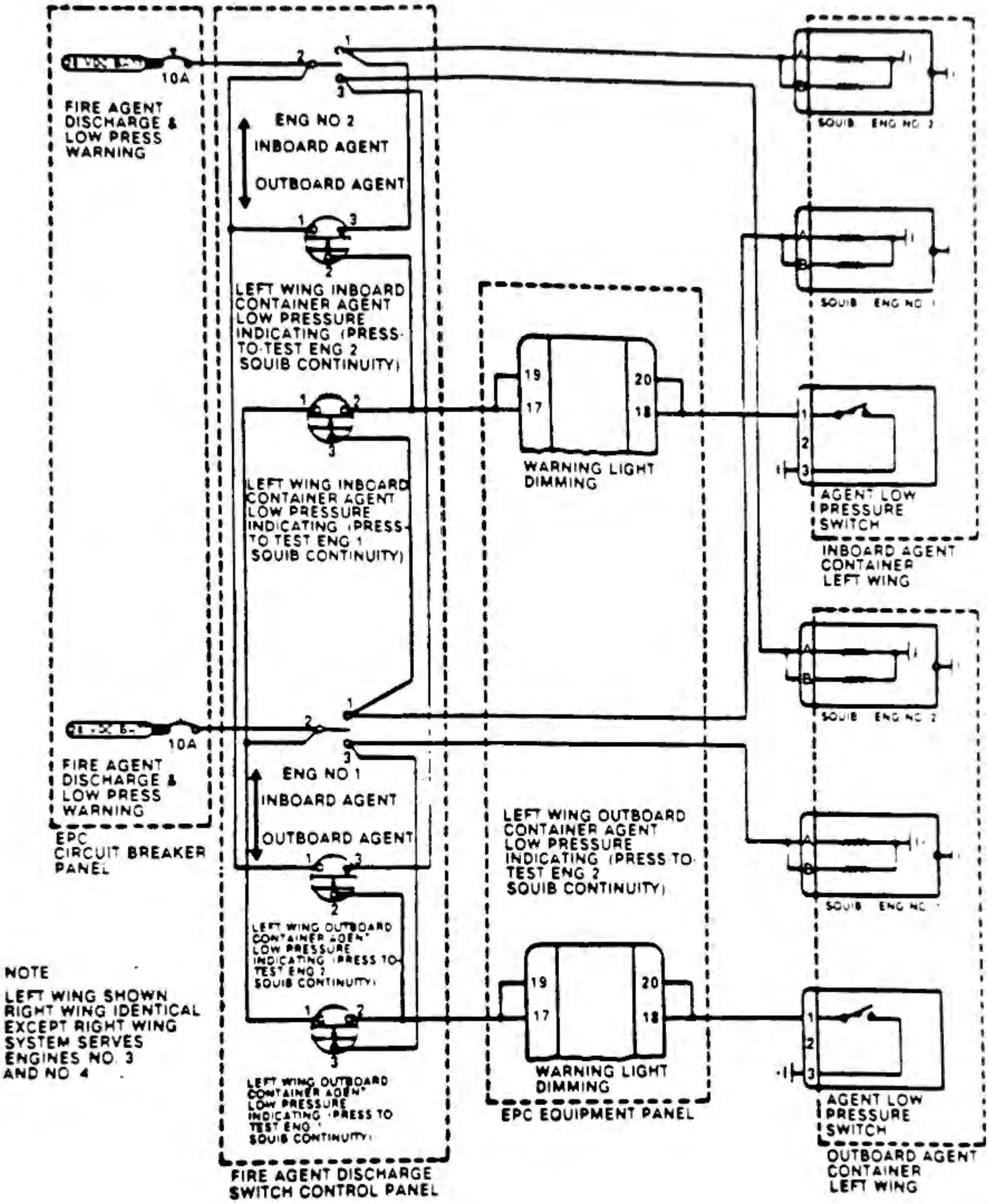
FTX80912

Figure 1-82

(6) The fire extinguishing agent discharge control panel is located aft of the overhead switch panel in the flight compartment and is guarded by clear plastic covers. The panel contains four extinguishing agent discharge switches and eight amber press-to-test extinguishing agent pressure low indicating lights. Switch numbers correspond to engine compartments. When switches are positioned aft, the corresponding inboard fire extinguishing agent container is discharged. When the switch is positioned forward, the outboard container of the same wing fire extinguishing system is discharged. The extinguishing agent pressure low indicating light press-to-test circuits are completed through the corresponding agent container explosive cartridge squibs. Integrity of the press-to-test light and agent discharge circuits can be checked without firing the explosive cartridges in the fire extinguishing agent containers.

C. Operation (See Figure 1-83)

Fire extinguishing agent discharge in an engine compartment is initiated by moving the fire control handle to the select agent position which opens the corresponding agent discharge control switch cover. The agent discharge control switch can be moved to either the inboard or outboard agent container discharge position. Electrically fused squibs, contained in the extinguishing agent discharge valve explosive cartridge, fire a slug through a frangible seal disc in the extinguishing agent container discharge port. The extinguishing agent flows under pressure through deployment lines to the engine compartment distribution nozzles.


10A
FIRE AGENT DISCHARGE & LOW PRESS WARNING
2
1
3
ENG NO 2
INBOARD AGENT
OUTBOARD AGENT
LEFT WING INBOARD CONTAINER AGENT LOW PRESSURE INDICATING (PRESS-TO-TEST ENG 2 SQUIB CONTINUITY)
LEFT WING INBOARD CONTAINER AGENT LOW PRESSURE INDICATING (PRESS-TO TEST ENG 1 SQUIB CONTINUITY)
10A
FIRE AGENT DISCHARGE & LOW PRESS WARNING
EPC CIRCUIT BREAKER PANEL
ENG NO 1
INBOARD AGENT
OUTBOARD AGENT
LEFT WING OUTBOARD CONTAINER AGENT LOW PRESSURE INDICATING (PRESS TO TEST ENG 2 SQUIB CONTINUITY)
LEFT WING OUTBOARD CONTAINER AGENT LOW PRESSURE INDICATING (PRESS TO TEST ENG 1 SQUIB CONTINUITY)
FIRE AGENT DISCHARGE SWITCH CONTROL PANEL
19
17
20
18
WARNING LIGHT DIMMING
LEFT WING OUTBOARD CONTAINER AGENT LOW PRESSURE INDICATING (PRESS TO TEST ENG 2 SQUIB CONTINUITY)
19
17
20
18
WARNING LIGHT DIMMING
EPC EQUIPMENT PANEL
A
B
SQUIB ENG NO 2
A
B
SQUIB ENG NO 1
1
2
3
AGENT LOW PRESSURE SWITCH
INBOARD AGENT CONTAINER LEFT WING
A
B
SQUIB ENG NO 2
A
B
SQUIB ENG NO 1
1
2
3
AGENT LOW PRESSURE SWITCH
OUTBOARD AGENT CONTAINER LEFT WING

NOTE
LEFT WING SHOWN
RIGHT WING IDENTICAL
EXCEPT RIGHT WING
SYSTEM SERVES
ENGINES NO. 3
AND NO. 4

FIRE AGENT DISCHARGE AND AGENT PRESSURE LOW INDICATING

FTX80913

Figure 1-83

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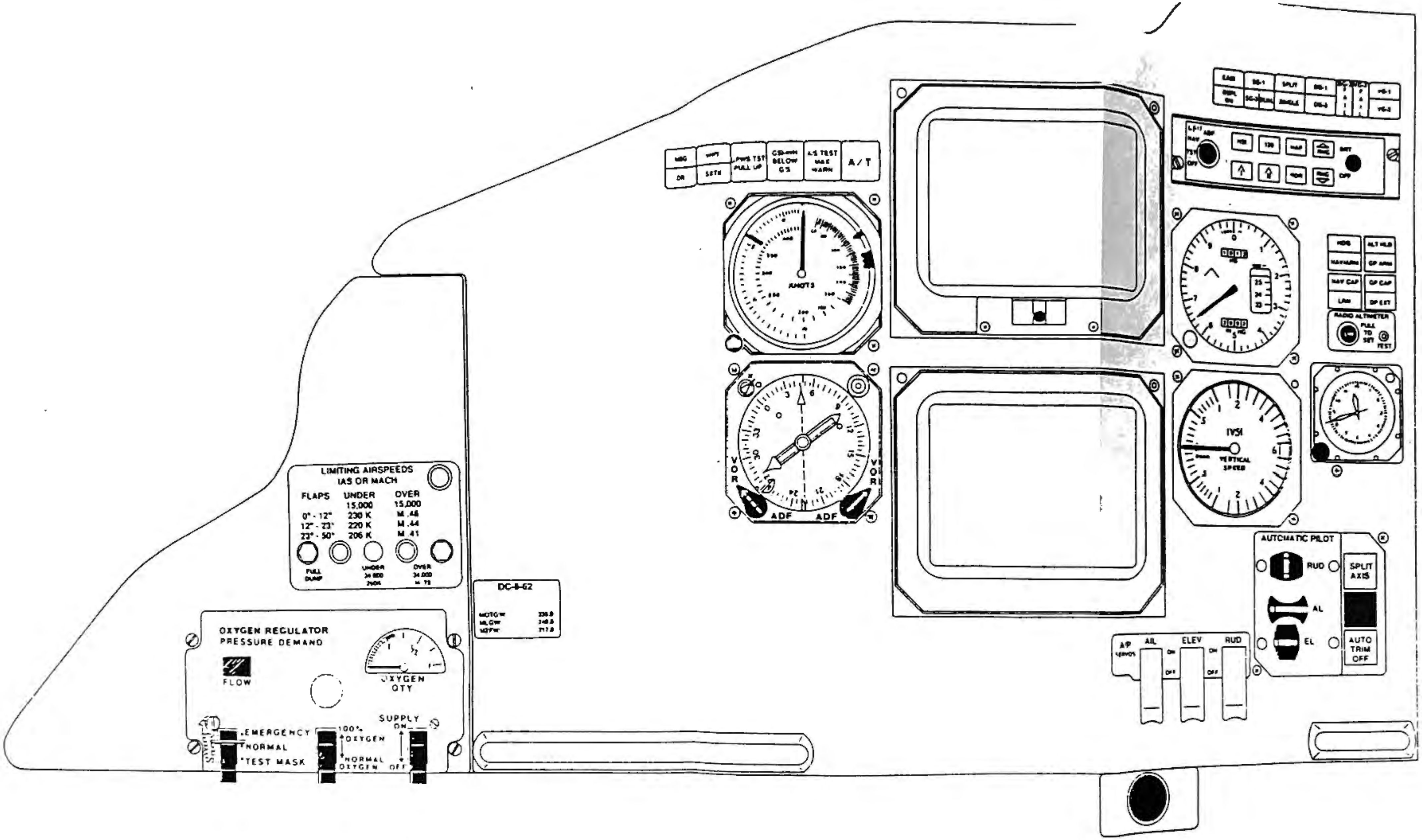
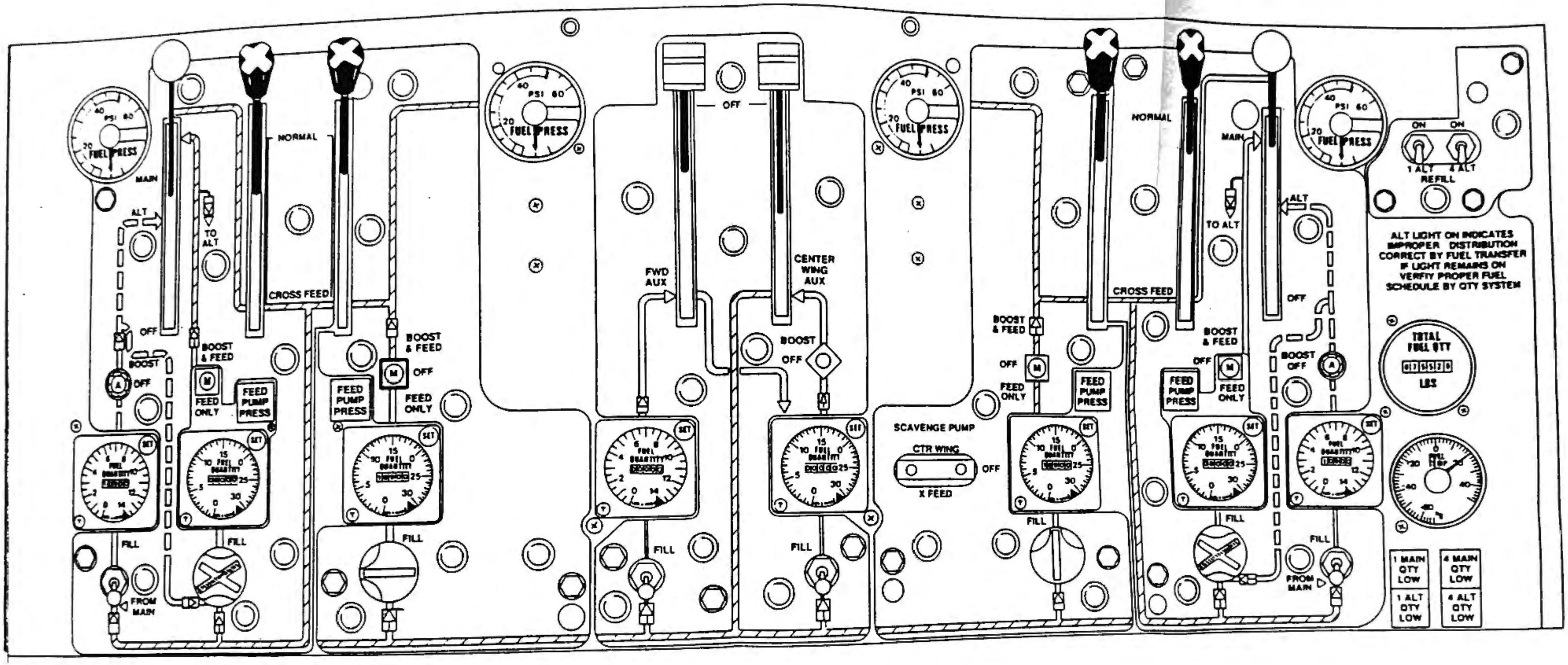
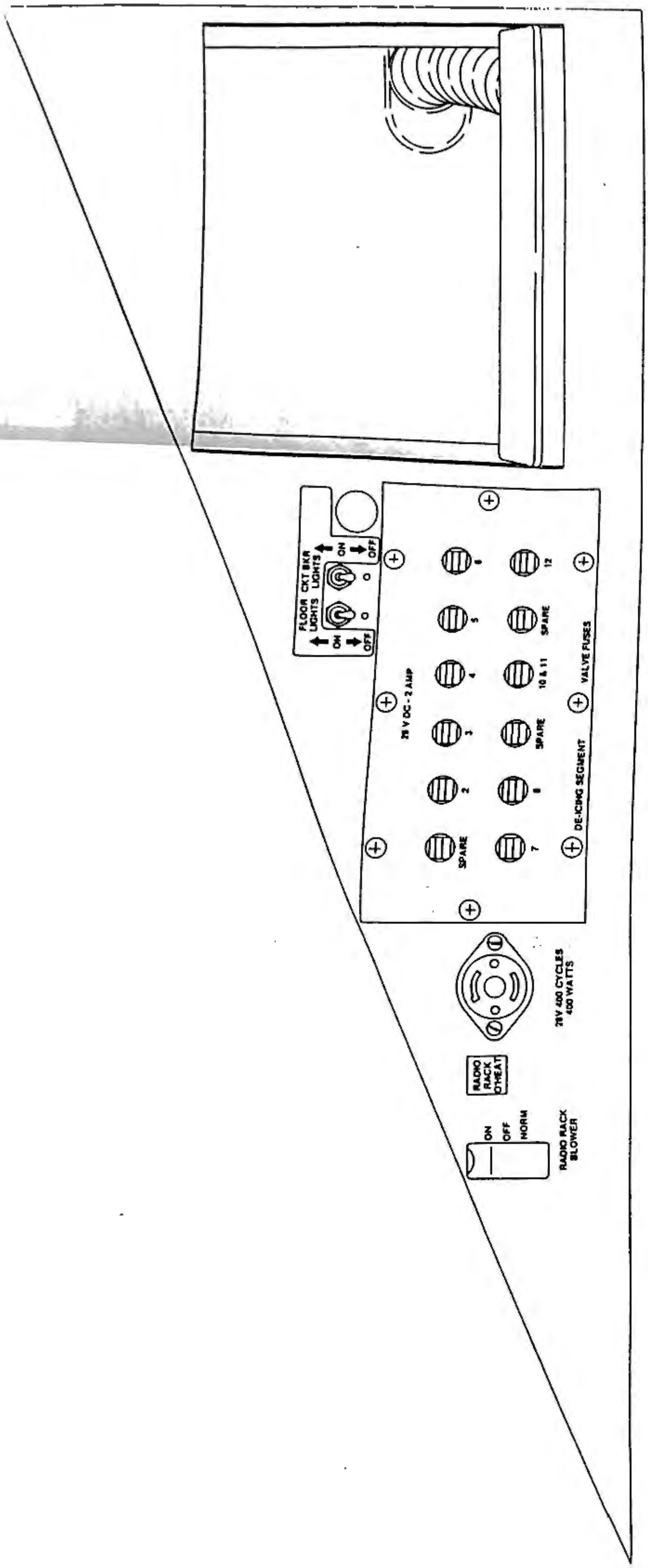
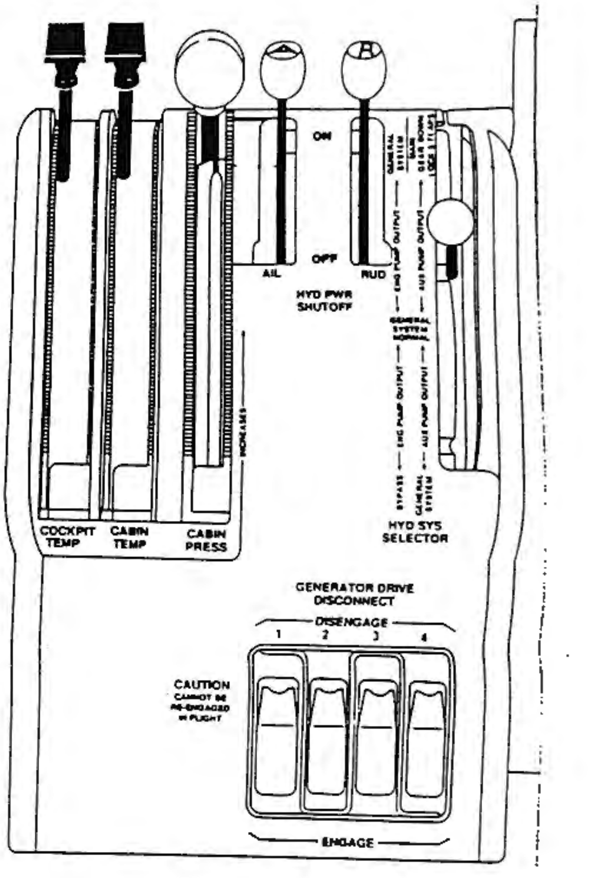


DC-8 CAPT INSTRUMENT



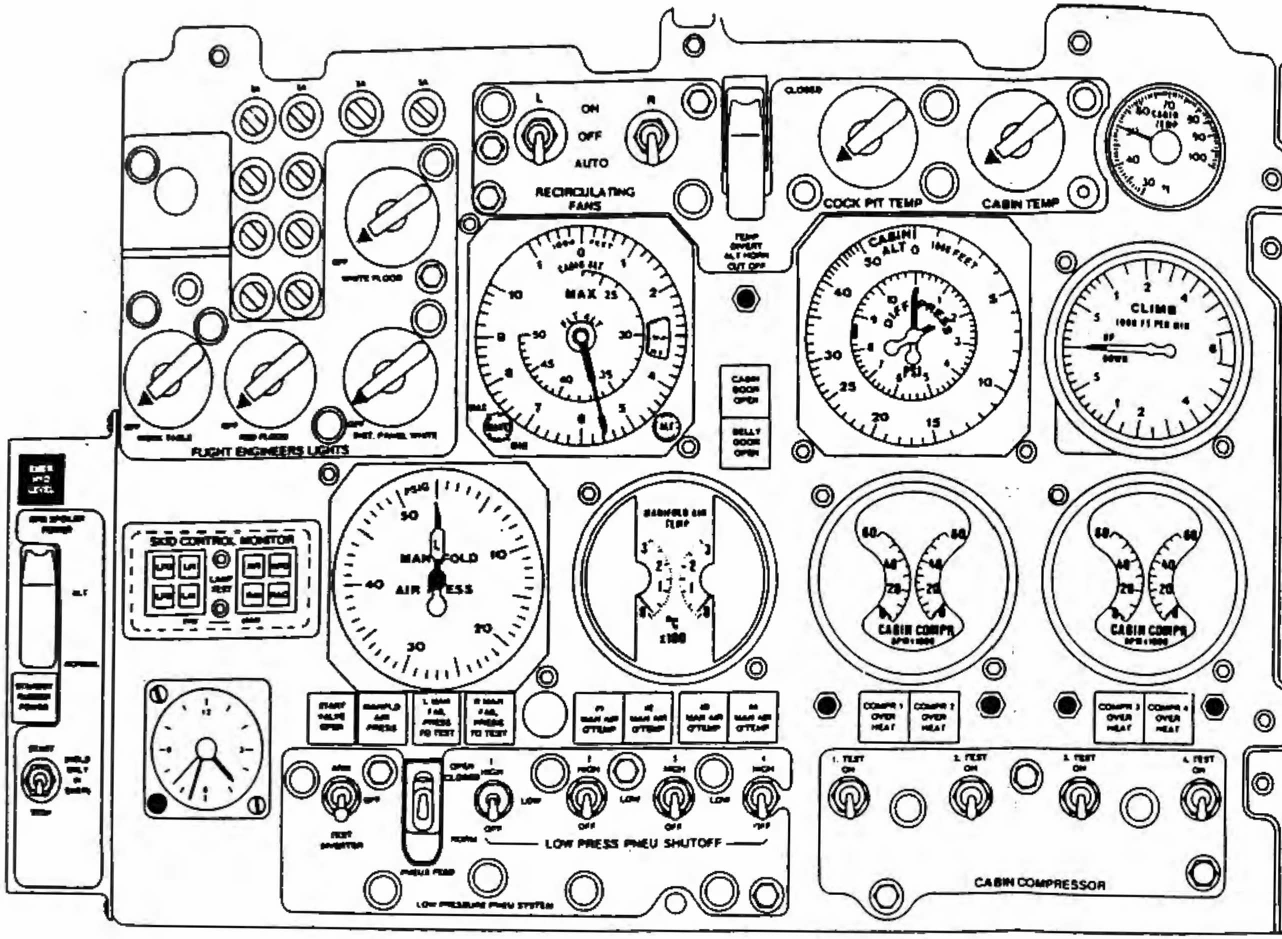
F/E FUEL MGMT PANEL



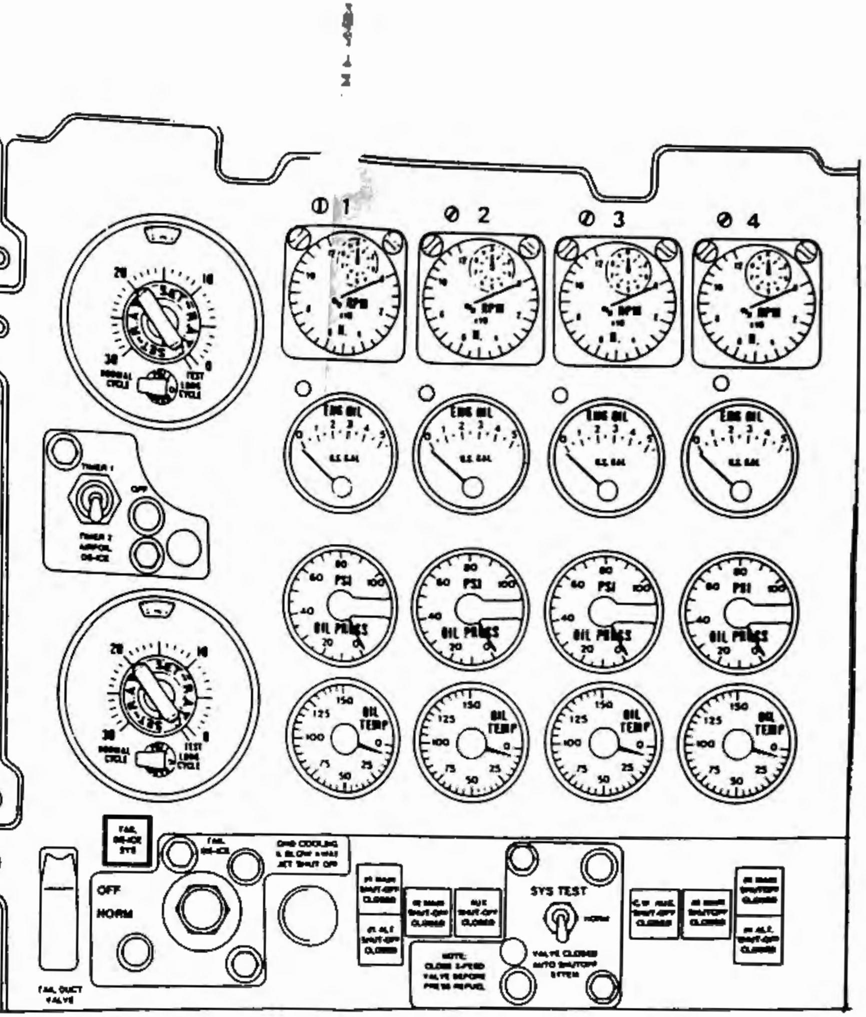


F/E CONT PEDESTAL

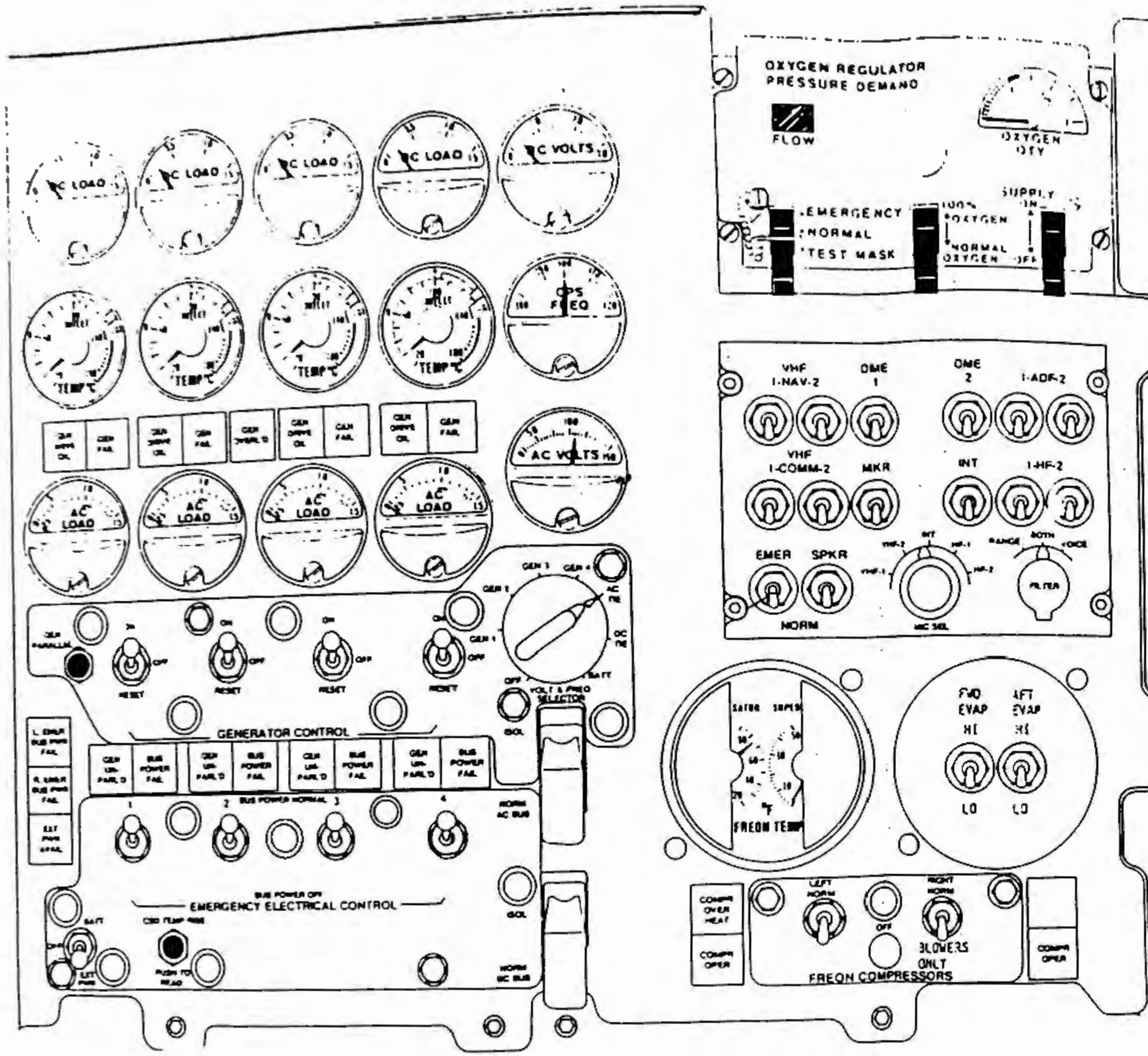
FTX80883



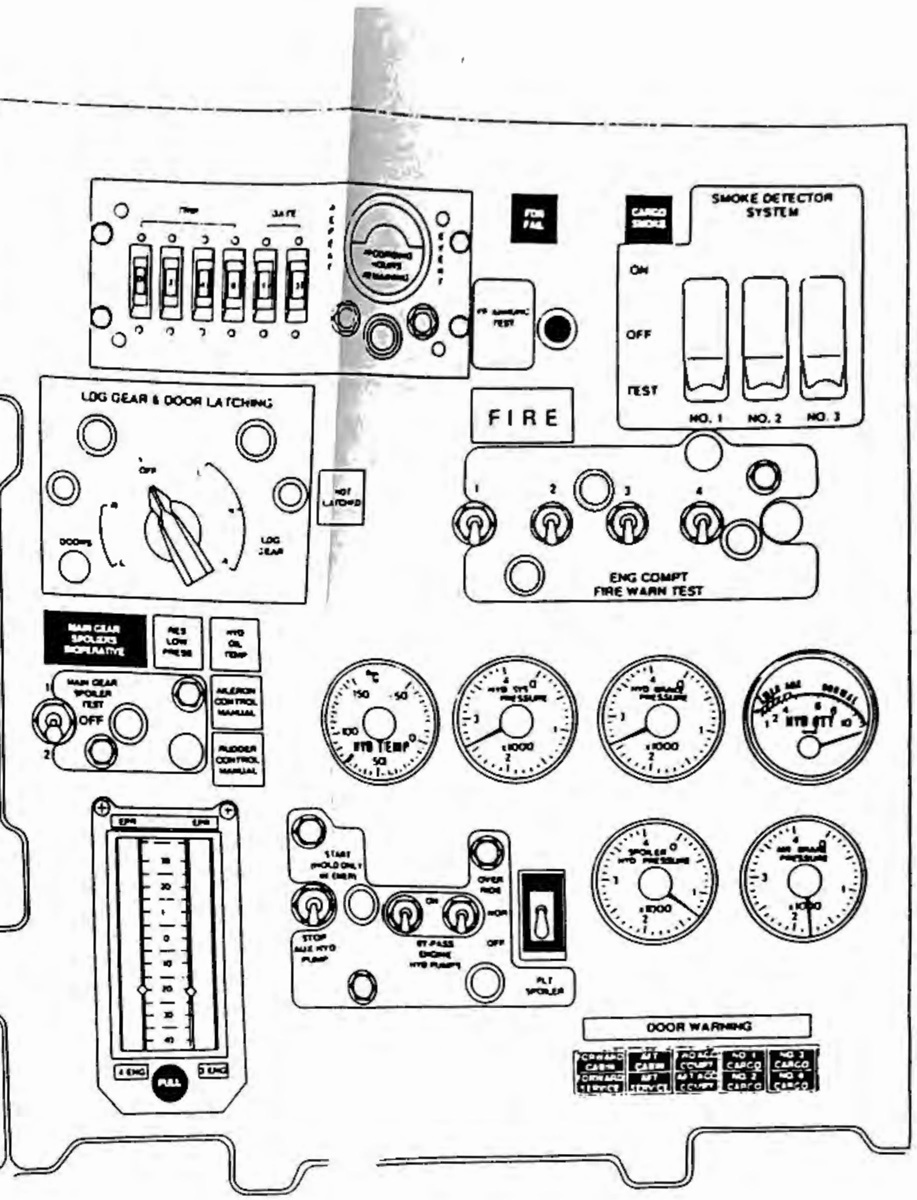
F/E LWR LEFT INST PNL



F/E LWR



F/E UPPER LT INST PNL



F/E UPPER RT NL

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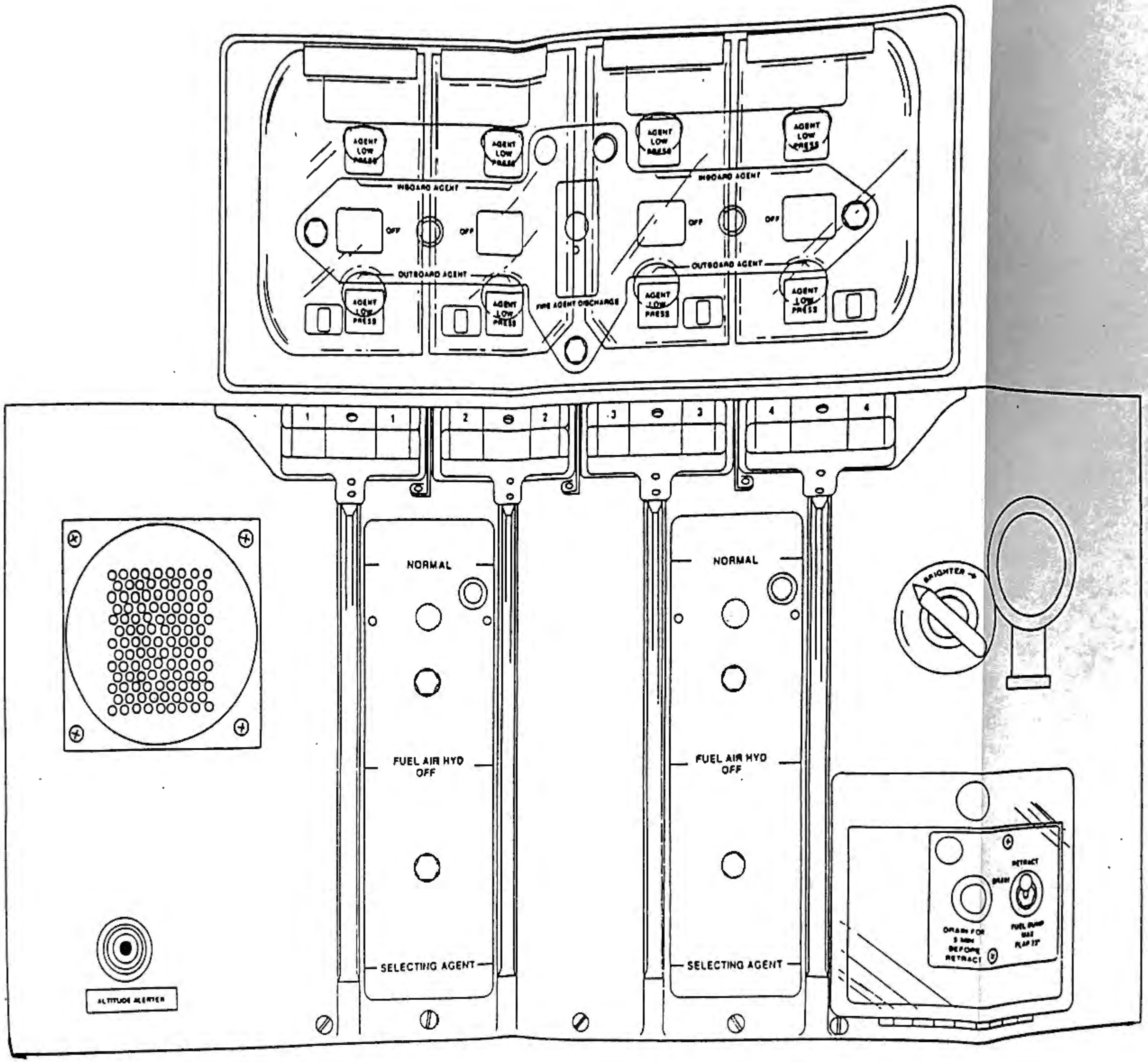
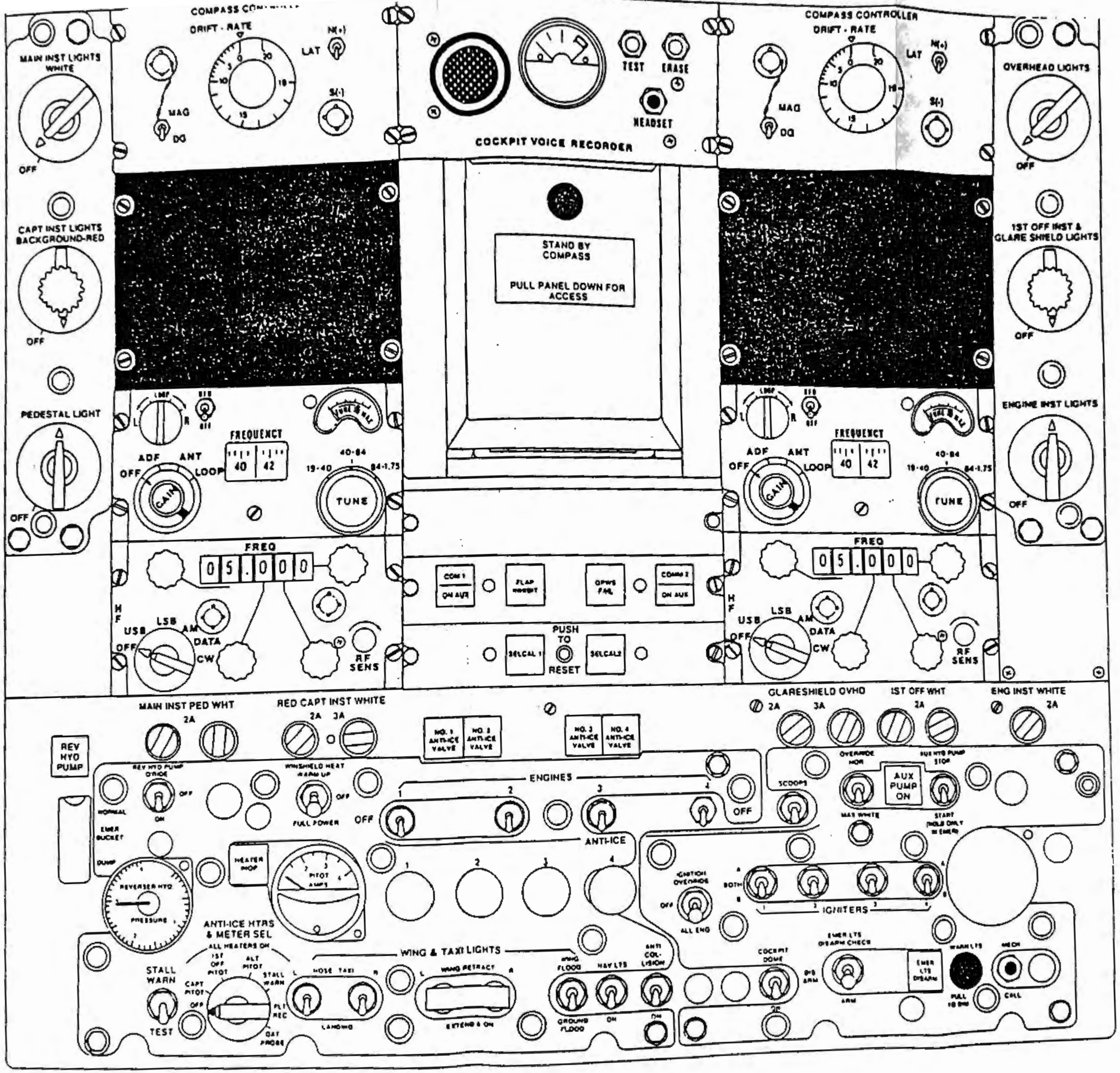
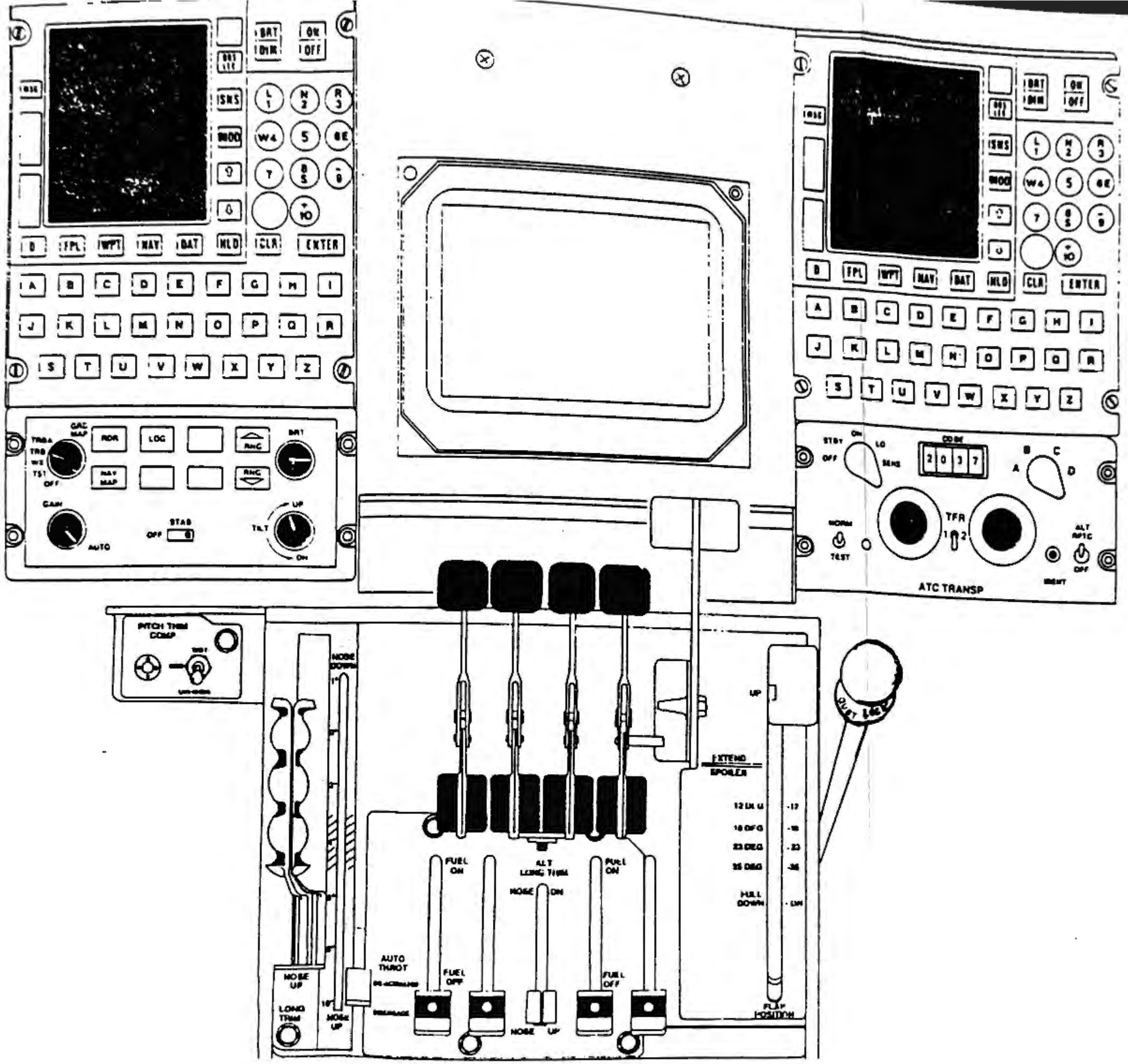


DC-8 AFT OVHD

FTX80886

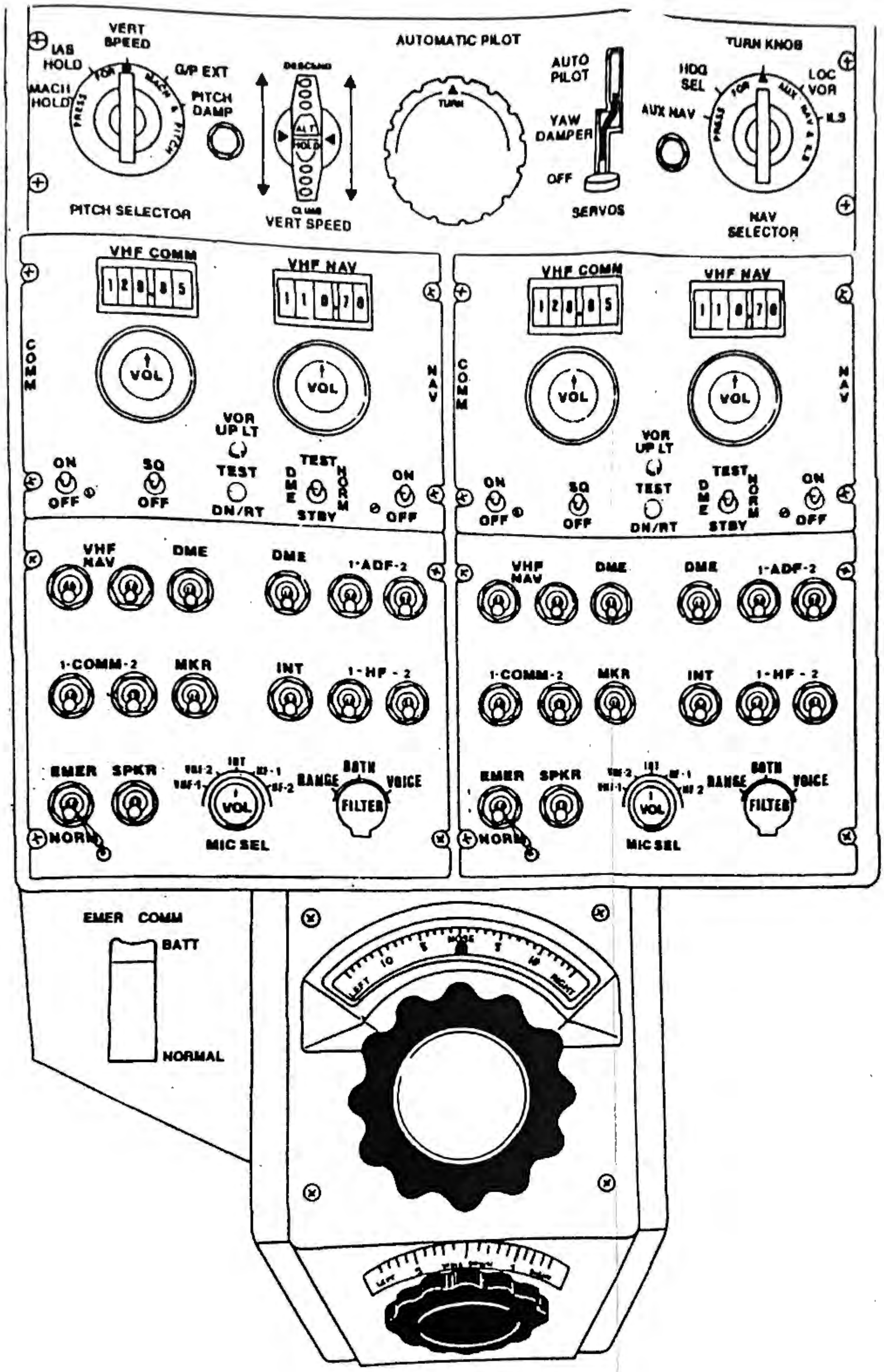

COMPASS CONTROLLER
DRIFT - RATE
LAT
N(+)
S(-)
MAG
DG
MAIN INST LIGHTS WHITE
OFF
CAPT INST LIGHTS BACKGROUND-RED
OFF
PEDESTAL LIGHT
OFF
TEST
ERASE
HEADSET
COCKPIT VOICE RECORDER
STAND BY COMPASS
PULL PANEL DOWN FOR ACCESS
COMPASS CONTROLLER
DRIFT - RATE
LAT
N(+)
S(-)
MAG
DG
OVERHEAD LIGHTS
OFF
1ST OFF INST & GLARE SHIELD LIGHTS
OFF
ENGINE INST LIGHTS
OFF
LOOP
FREQUENCY
40
42
ADF
ANT
OFF
LOOP
GAIN
40-84
19-40
84-1.75
TUNE
FREQ
05.000
H F
USB
LSB
AM
OFF
DATA
CW
RF SENS
COMM 1 ON AUX
FLAP WARNING
GPWS FAIL
COMM 2 ON AUX
PUSH TO RESET
SELCAL 1
SELCAL 2
MAIN INST PED WHT
2A
RED CAPT INST WHITE
2A
3A
GLARESHIELD OVHD
2A
3A
1ST OFF WHT
2A
ENG INST WHITE
2A
REV HYD PUMP
NO. 1 ANTI-ICE VALVE
NO. 2 ANTI-ICE VALVE
NO. 3 ANTI-ICE VALVE
NO. 4 ANTI-ICE VALVE
REV HYD PUMP O'RIDE
OFF
ON
NORMAL
EMER BUCKET
DUMP
WINSHIELD HEAT
WARM UP
OFF
FULL POWER
ENGINES
1
2
3
4
OFF
OFF
SCOOPS
OVERRIDE
NOR
MAX WHITE
AUX PUMP ON
AUX HYD PUMP STOP
START
HEATER INOP
REVERSER HYD
PRESSURE
PITOT AMPS
ANTI-ICE
1
2
3
4
IGNITION OVERRIDE
OFF
ALL ENG
BOTH
A
B
IGNITERS
1
2
3
4
ANTI-ICE HTRS & METER SEL
ALL HEATERS ON
1ST OFF PITOT
ALT PITOT
STALL WARN
CAPT PITOT
OFF
FLT REC
OAT PROBE
STALL WARN
TEST
WING & TAXI LIGHTS
L
NOSE
TAXI
R
LANDING
WING RETRACT
EXTEND & ON
WING FLOOD
NAV LTS
ANTI COL-LISION
GROUND FLOOD
ON
ON
COCKPIT DOME
EMER LTS DISARM CHECK
DIS ARM
ARM
EMER LTS DISARM
WARN LTS
PULL TO DIM
MECH
CALL

DC-8 FWD OVHD



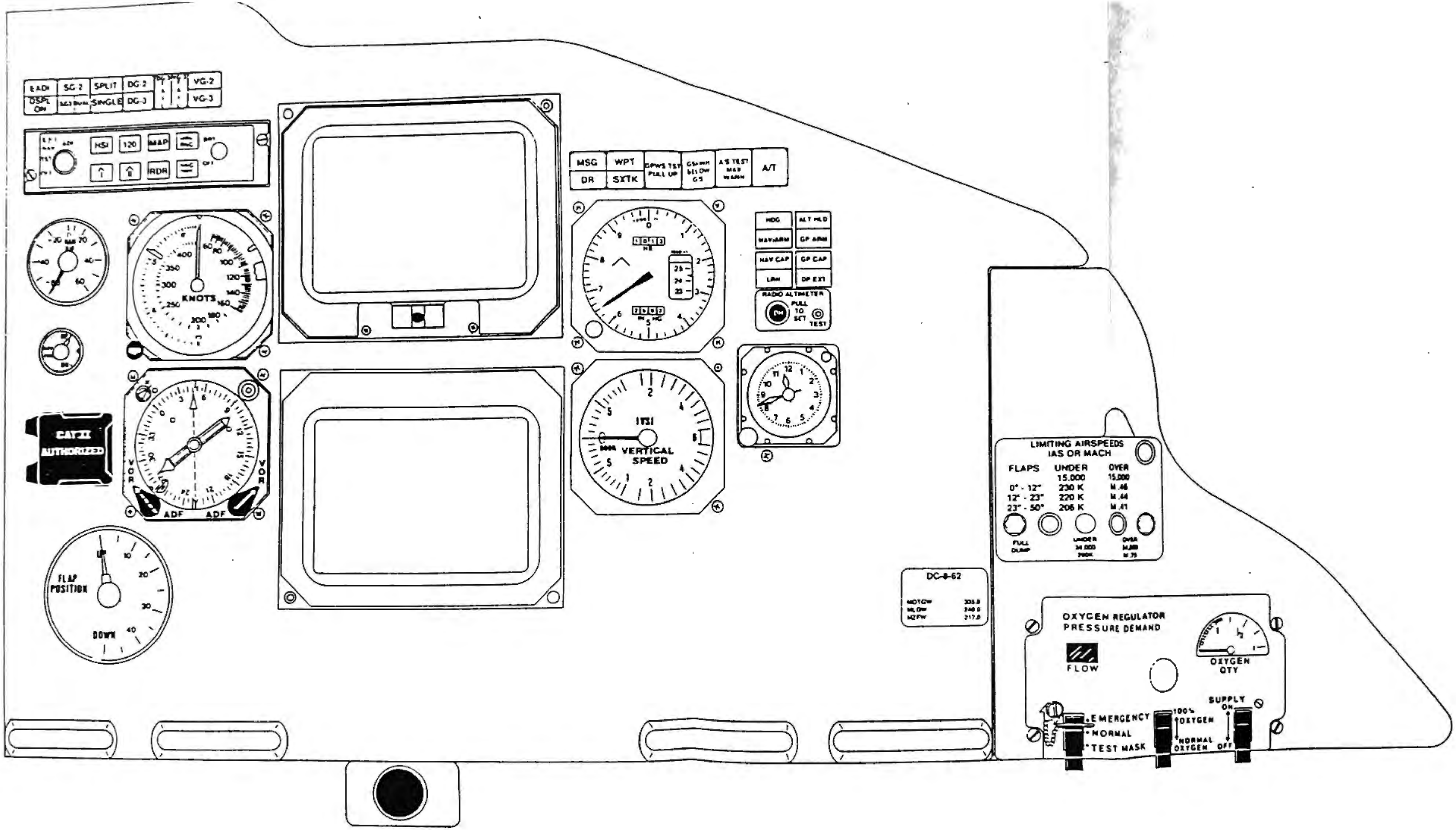
DC-8 FWD PEDESTAL

FTX80888



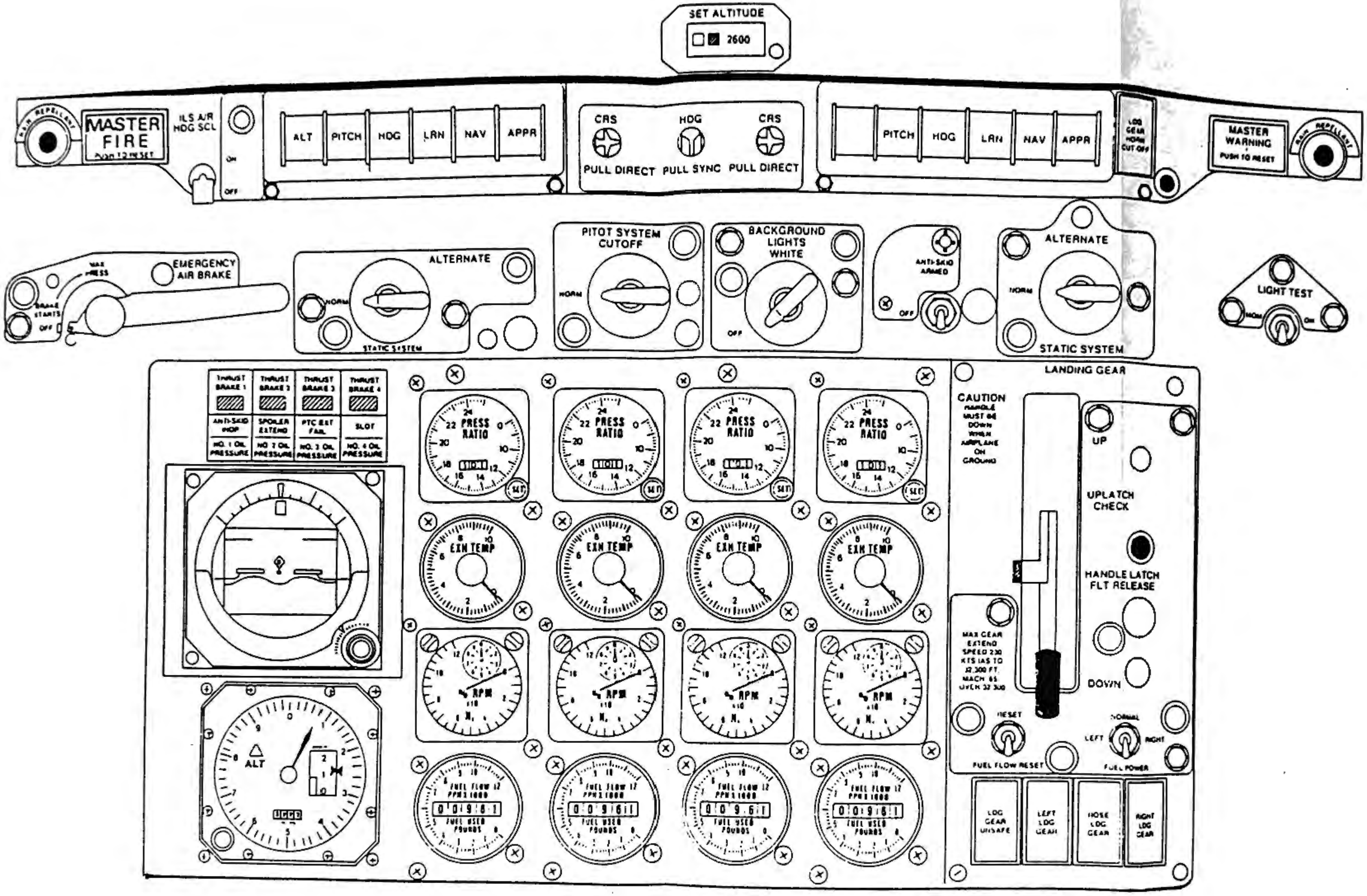
DC-8 CTR PEDESTAL

FTX80889



DC-8 F/O'S INST

FTX80890



DC-8 CTR INSTRUMENT

FTX80891

ELECTRICAL

1. General - Description and Operation

A. Description (See Figure 24-1)

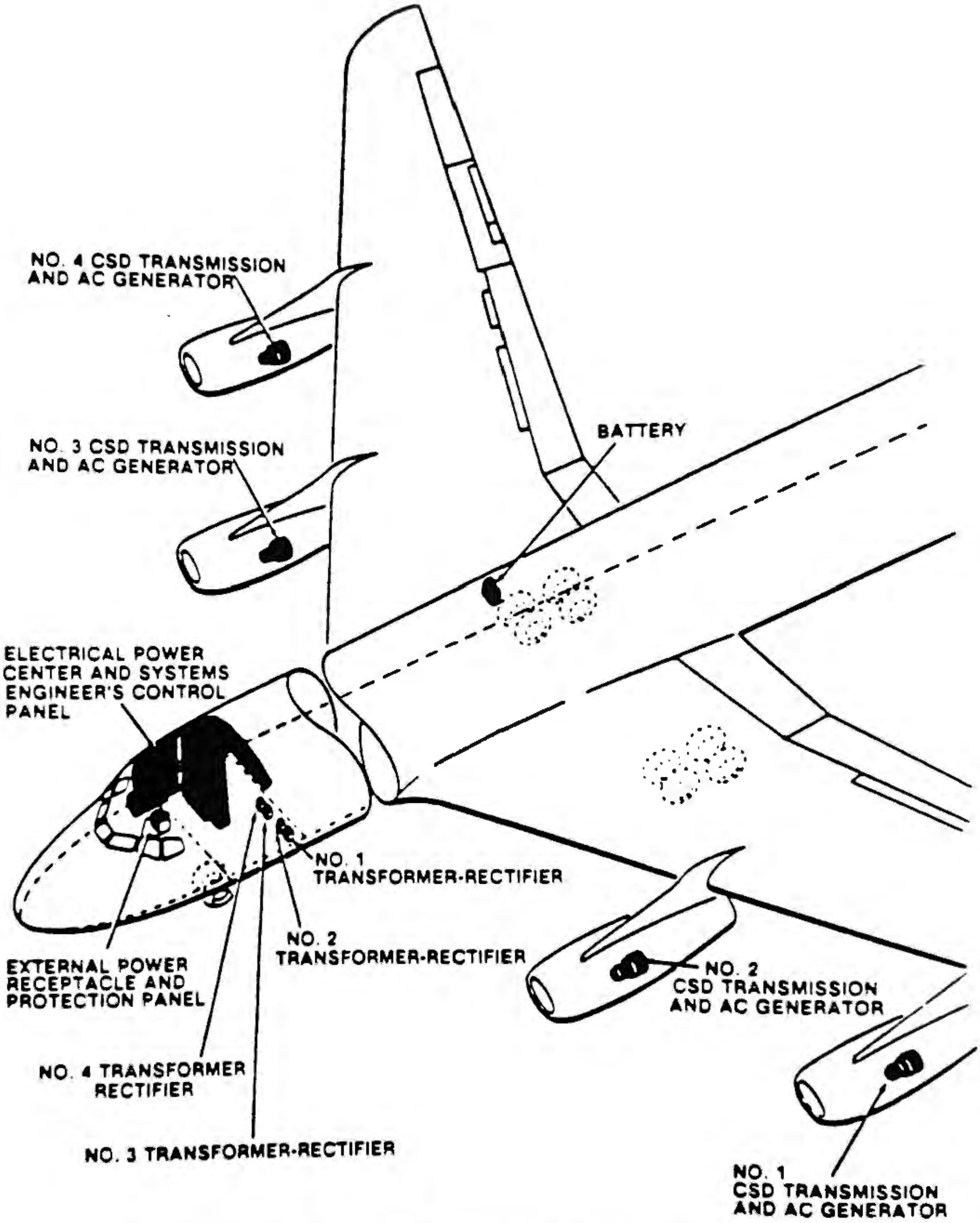
(1) Electrical power used on the airplane consists of alternating current and direct current generation with corresponding distribution systems. Four brushless, air-cooled, engine-driven, AC generators provide 115/200 volt, 3-phase, 400-cycle per second (cps) alternating current. The 28-volt direct current requirements are met by four 50- ampere, unregulated transformer-rectifiers and a 24-volt, nickel-cadmium battery.

(2) Generator speeds are held constant at 6000 rpm, during all variations of engine speeds between idle and takeoff, by a gear-differential constant speed drive (CSD) transmission. Frequency is maintained at 400 (±4) cps by the CSD transmission speed governor.

(3) Transmission output rotation can be stopped, under specific procedures, by placing the corresponding generator CSD disconnect switch in the disconnected position. When disengaged, the transmission must not be re-engaged until the engine is shut down and comes to a complete stop. Re-engagement of the transmission is accomplished manually by pulling the disconnect reset handle until a stop is felt and then releasing the handle.

(4) The AC system is arranged so that each generator is connected through a generator relay to a corresponding generator bus (see Figure 24-2). Each generator bus is connected to the AC tie bus through a bus tie relay and to corresponding load buses through load monitor relays. In addition, the No. 2 generator bus is connected directly to the left AC emergency bus, and the No. 3 generator bus is connected directly to the right AC emergency bus.

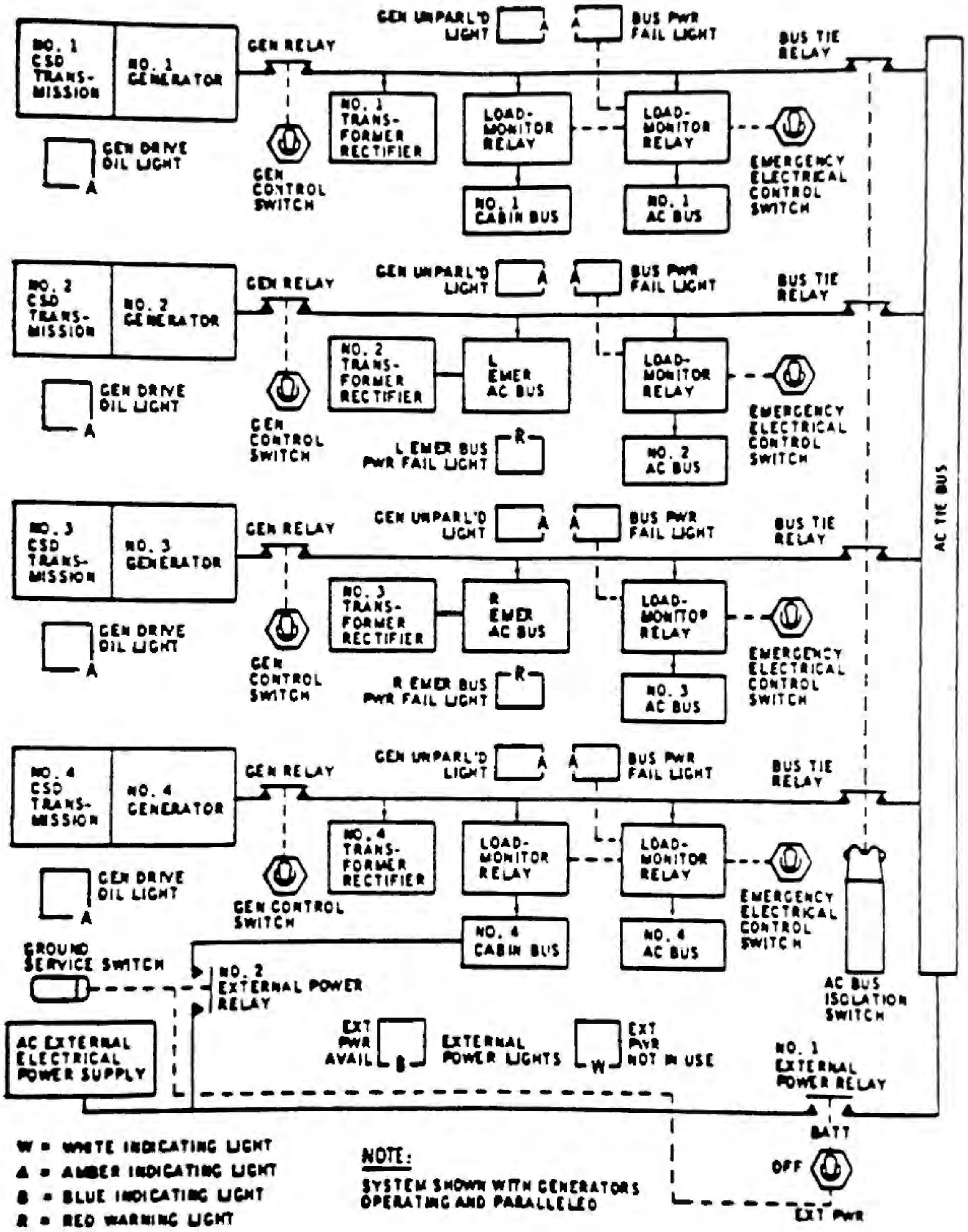
(5) The generators can be operated unparalleled as separate systems, each supplying power to corresponding buses, or paralleled with all operating generators equally sharing the total electrical loads. Paralleled operation is preferred. If a generator fails to function, continuity of electrical power to the dead bus is assured by the paralleling


NO. 4 CSD TRANSMISSION AND AC GENERATOR
NO. 3 CSD TRANSMISSION AND AC GENERATOR
BATTERY
ELECTRICAL POWER CENTER AND SYSTEMS ENGINEER'S CONTROL PANEL
NO. 1 TRANSFORMER-RECTIFIER
NO. 2 TRANSFORMER-RECTIFIER
EXTERNAL POWER RECEPTACLE AND PROTECTION PANEL
NO. 2 CSD TRANSMISSION AND AC GENERATOR
NO. 4 TRANSFORMER RECTIFIER
NO. 3 TRANSFORMER-RECTIFIER
NO. 1 CSD TRANSMISSION AND AC GENERATOR

ELECTRICAL POWER SYSTEM INSTALLATIONS

FTX80001

Figure 24-1



NOTE:
SYSTEM SHOWN WITH GENERATORS OPERATING AND PARALLELED

AC POWER DISTRIBUTION - BLOCK DIAGRAM

FTX80002

Figure 24-2

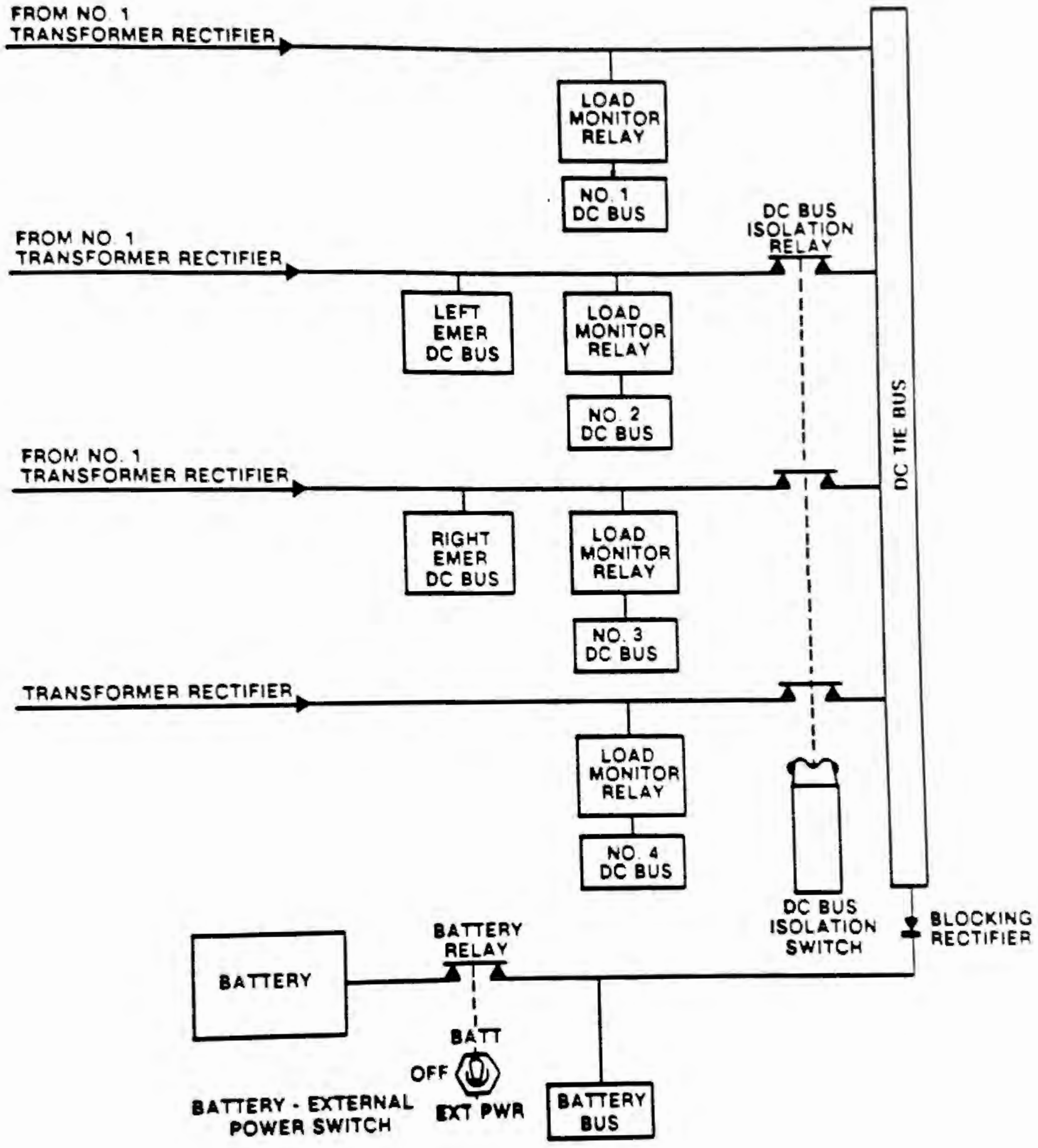
circuit which initiates an equal load distribution among the remaining operating generators. An AC bus isolation switch can be operated to isolate the AC buses and to prevent parallel operation.

(6) During unparalleled operation, power supply to the AC tie bus is assured by the preferential circuit if the AC bus isolation switch is closed. The preferential order is 2-3-1-4; and the first operative generator in that order, always starting with No. 2, connects to the AC tie bus. If a generator fails to function during unparalleled operation, the generator supplying power to the AC tie bus will also supply power to the dead buses of the failed generator.

(7) The DC system is supplied power from four 50-ampere, unregulated transformer-rectifier units which convert AC to DC for the required 28-volt direct current loads (see figure 24-3). The input is 3-phase, 400-cps, 115-volt AC power; the output is 28-volt DC power. Power from each transformer-rectifier is supplied to a corresponding load bus through a load monitor relay. Power is also supplied to the DC tie bus directly from the No. 1 transformer-rectifier and through isolation relays from No. 2, 3, and 4 transformer-rectifiers. Power from No. 2 and 3 transformer-rectifiers is supplied directly to the left and right DC emergency buses, respectively. The transformer-rectifiers normally operate in parallel. A DC bus isolation switch can be operated for unparalleled operation.

(8) All AC and DC load buses can be disconnected from the respective power sources by actuation of emergency electrical control switches. If the generators are operating in parallel when the switches are actuated, the generators continue to operate in parallel to supply power to the left and right AC emergency buses through the AC tie bus and the AC bus tie relays. All transformer-rectifiers continue to operate in parallel to supply power to the left and right DC emergency buses. If the generators are operating unparalleled when the emergency electrical control switches are actuated, power is supplied to the left and right AC emergency buses from the respective generator bus, and the transformer-rectifiers continue to operate in parallel to supply power to the left and right DC emergency buses. Only one AC bus and one DC bus need be energized for safe control of the airplane.

(9) The 24-volt DC system can also be supplied power from a 24-volt, nickel-cadmium battery. The battery is connected to the battery bus through a battery relay. The battery bus is normally powered from



FTX80003

Figure 24-3

the DC tie bus through a blocking rectifier. The blocking rectifier permits the battery to receive charging current when the DC tie bus is powered but prevents the battery from discharging into loads connected to the tie bus when the bus is not powered.

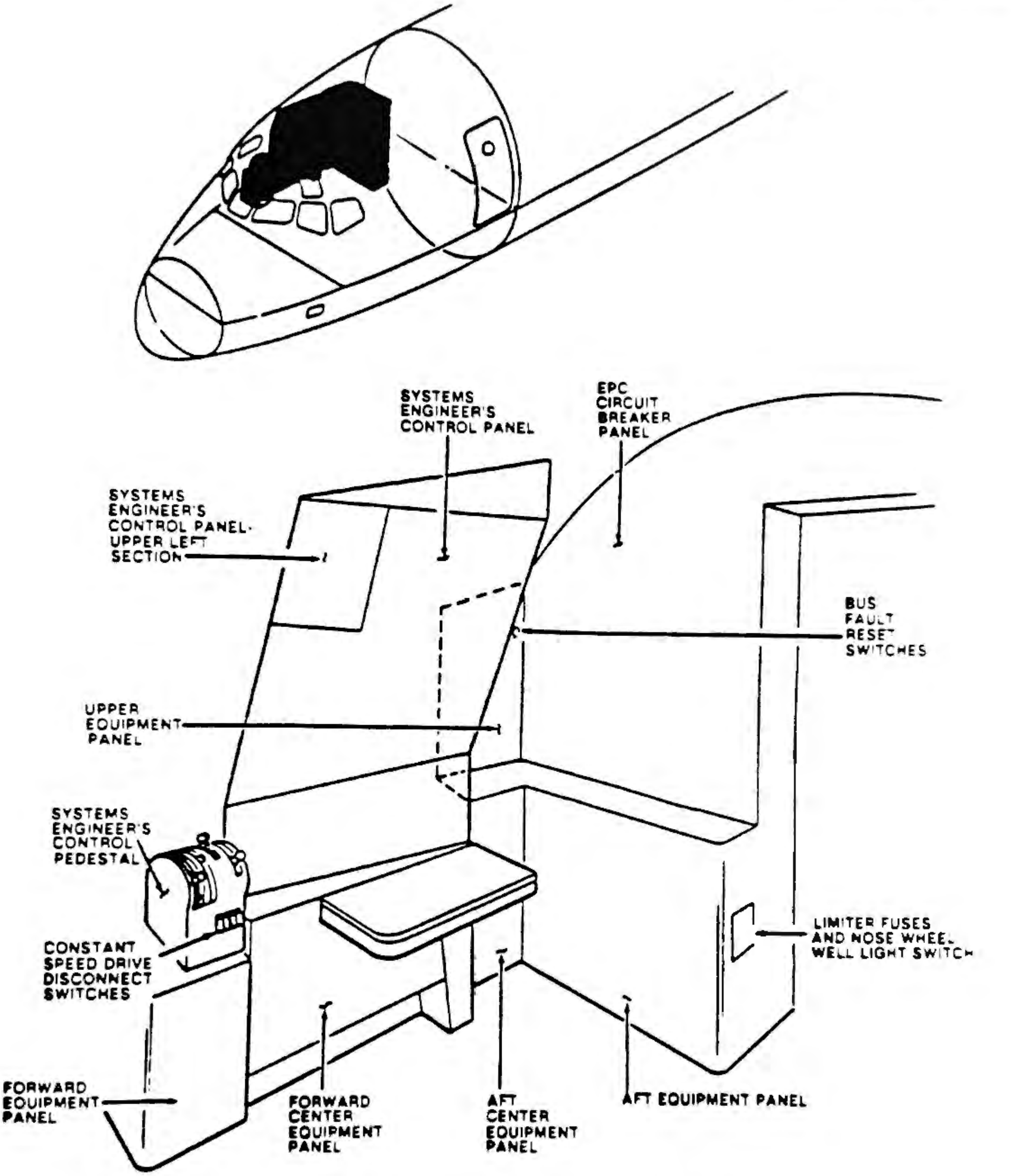
(10) An external power receptacle enable the connection of a 400-cycle, 3-phase, 115/200 -volt external power source to energize the airplane electrical circuits.

B. Controls and Indications (See Figure 24-4)

(1) The electrical power center and systems engineer's station provides a central location for electrical load distribution and contains the controls and indications for the individual systems used on the airplane.

(2) Bus fault reset switches are located on the upper equipment panel. Constant speed drive disconnect switches for disengaging each CSD transmission are located on the systems engineer's control pedestal. The circuit breaker buses, limiter fuses, generator control rack, and generator bus bays are located on the aft side of the electrical power center. (See Figure 24-5, 24-6, and 24-7)

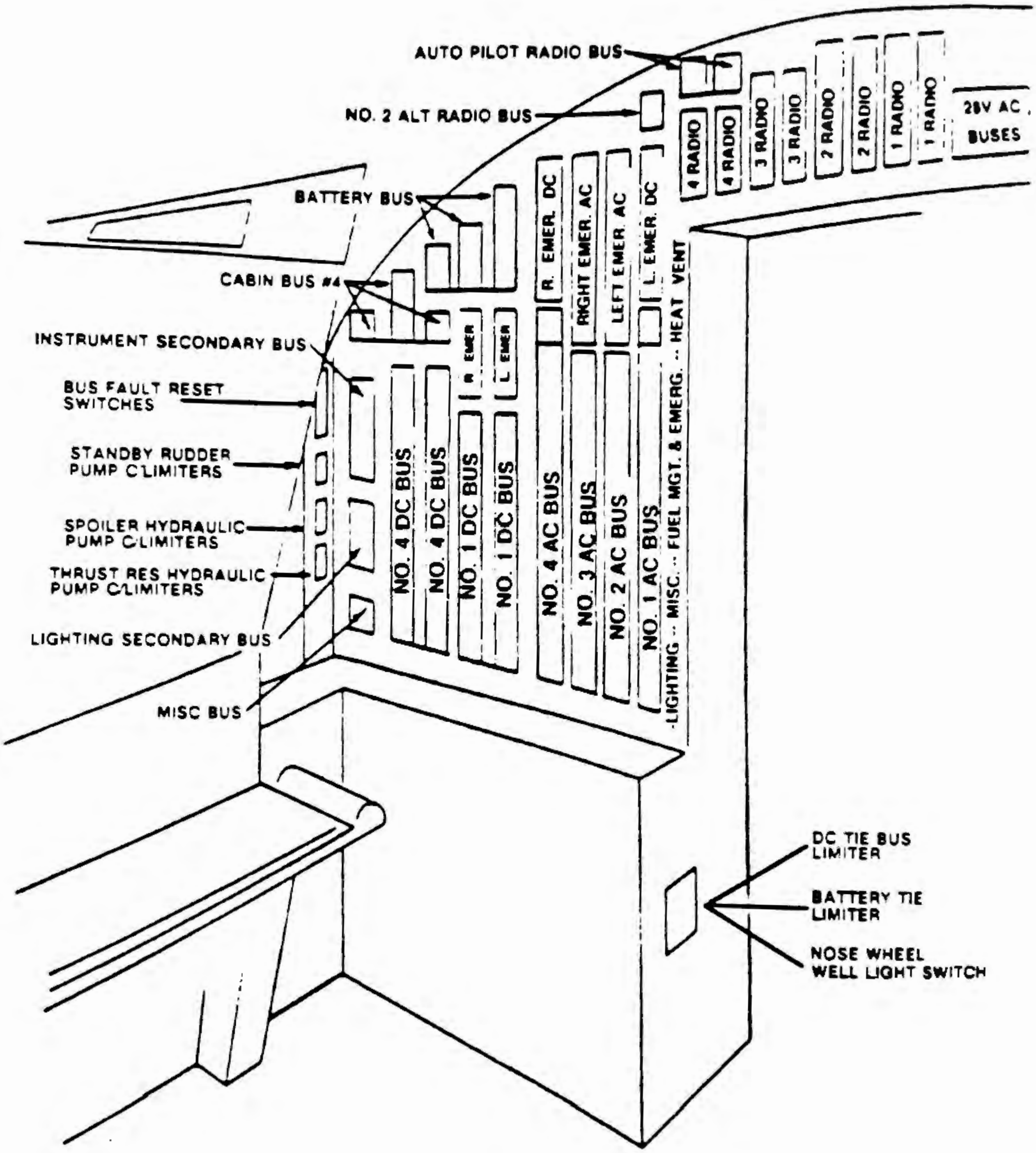
(3) Control switches, instruments, and indicating lights for monitoring and controlling the electrical power system are located on the upper left section of the system engineer's control panel (see Figure 24-8, 24-9, 24-10 and 24-11).


SYSTEMS ENGINEER'S CONTROL PANEL
EPC CIRCUIT BREAKER PANEL
SYSTEMS ENGINEER'S CONTROL PANEL-UPPER LEFT SECTION
BUS FAULT RESET SWITCHES
UPPER EQUIPMENT PANEL
SYSTEMS ENGINEER'S CONTROL PEDESTAL
LIMITER FUSES AND NOSE WHEEL WELL LIGHT SWITCH
CONSTANT SPEED DRIVE DISCONNECT SWITCHES
FORWARD EQUIPMENT PANEL
FORWARD CENTER EQUIPMENT PANEL
AFT CENTER EQUIPMENT PANEL
AFT EQUIPMENT PANEL

ELECTRICAL POWER CENTER AND
SYSTEMS ENGINEER'S STATION

FTX80004

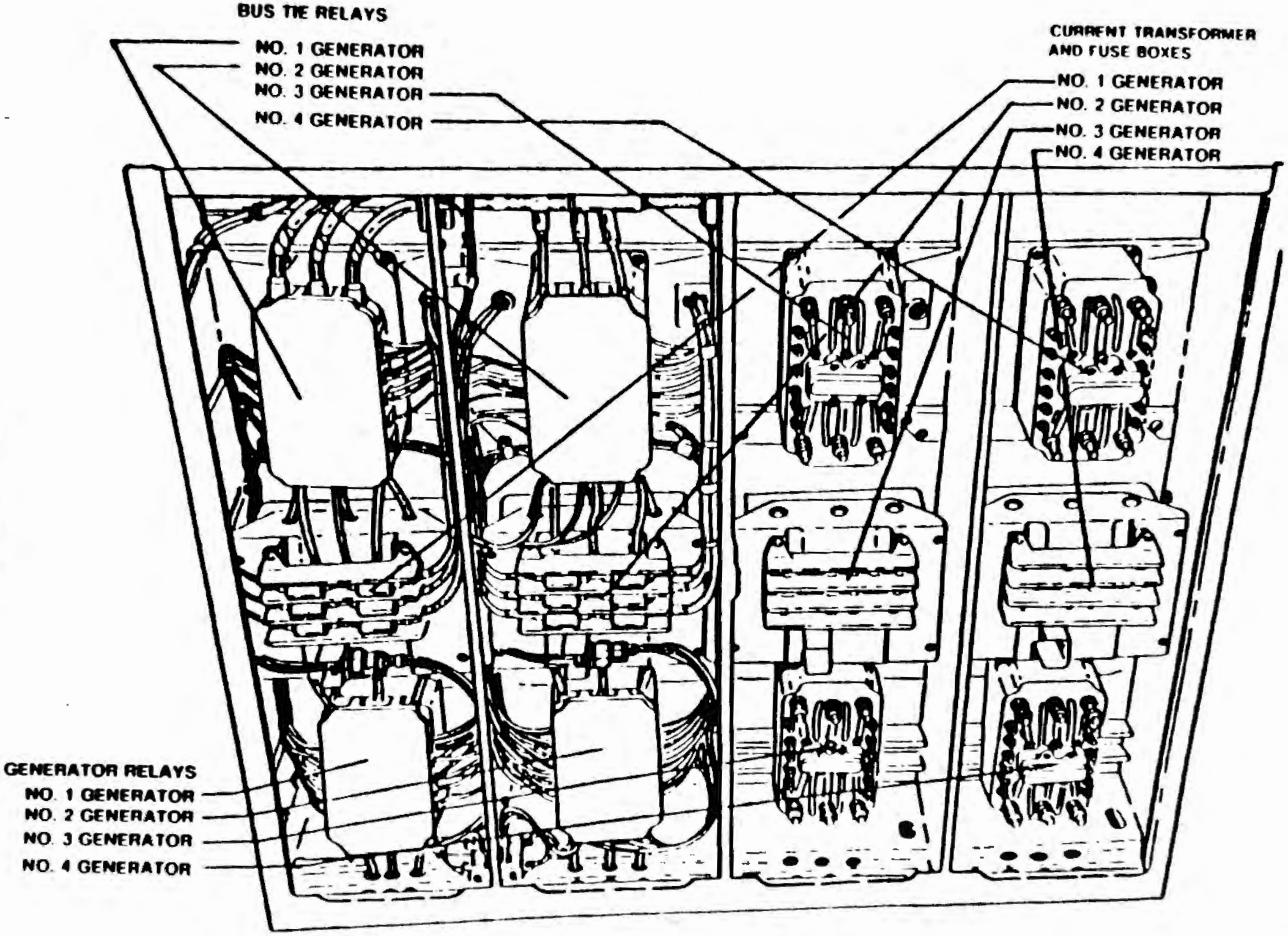
Figure 24-4



CIRCUIT BREAKER PANEL

FTX80005

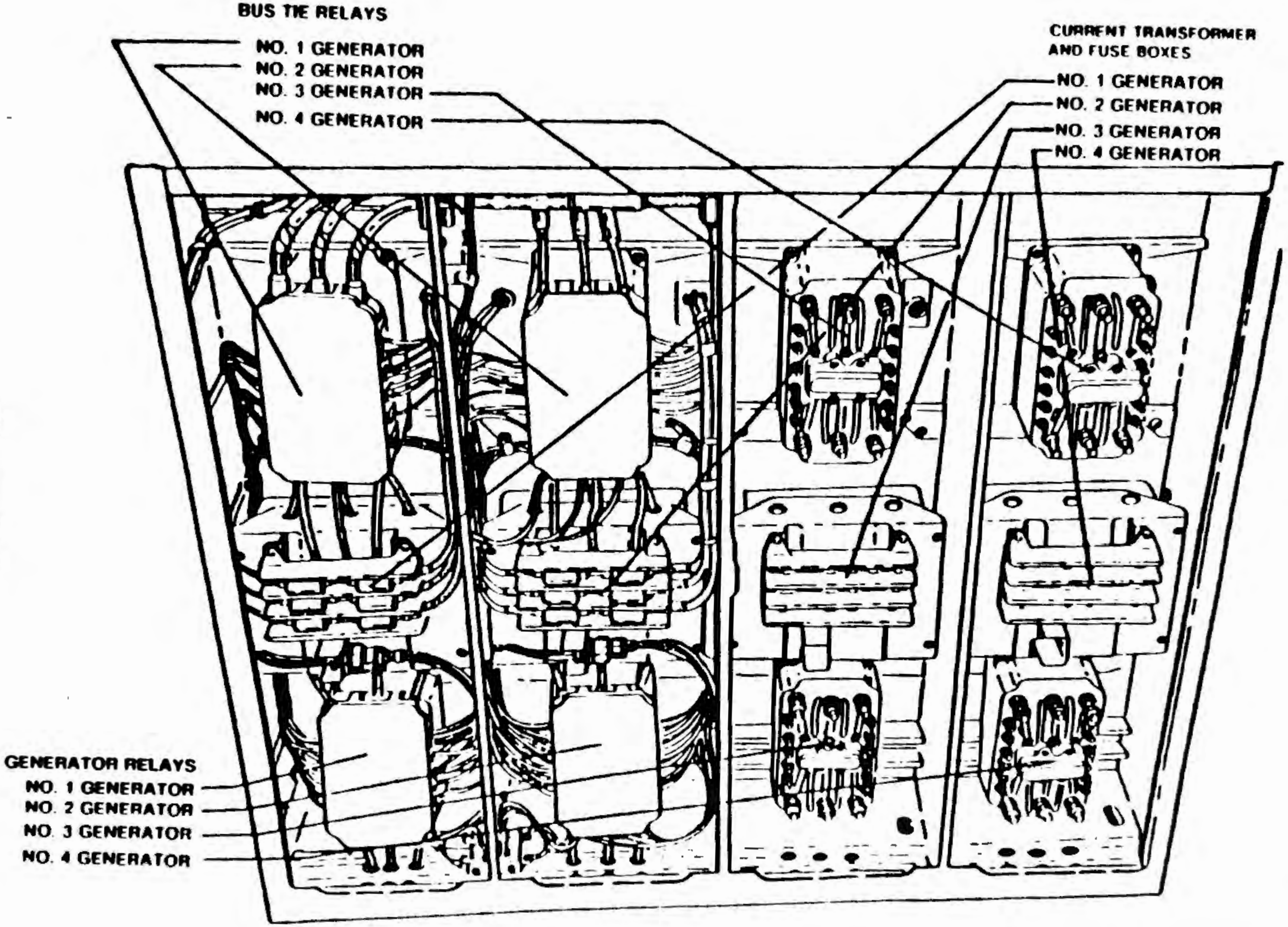
Figure 24-5



GENERATOR BUS BAYS

FTX80006

Figure 24-6



GENERATOR BUS BAYS

FTX80006

Figure 24-6

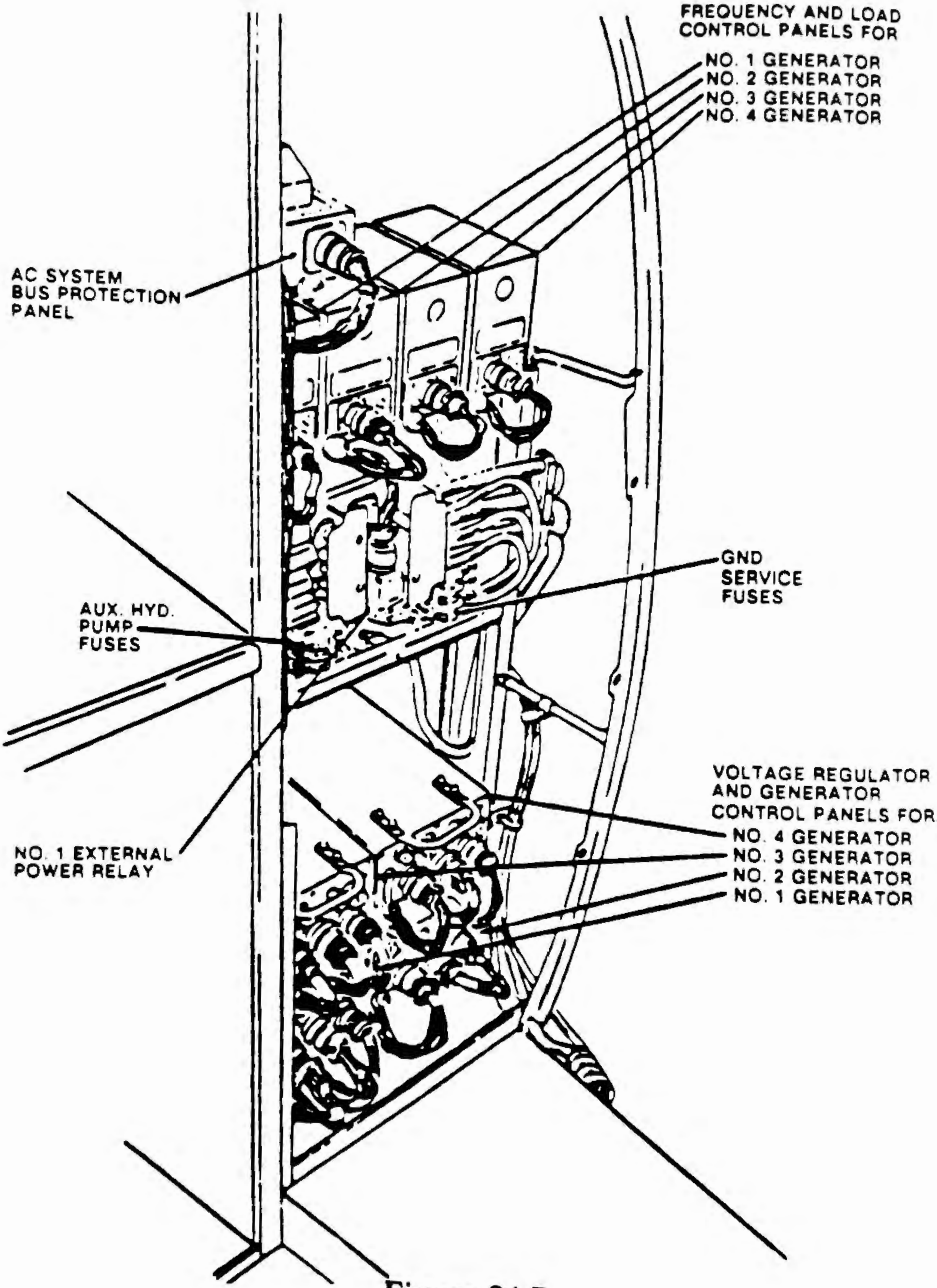
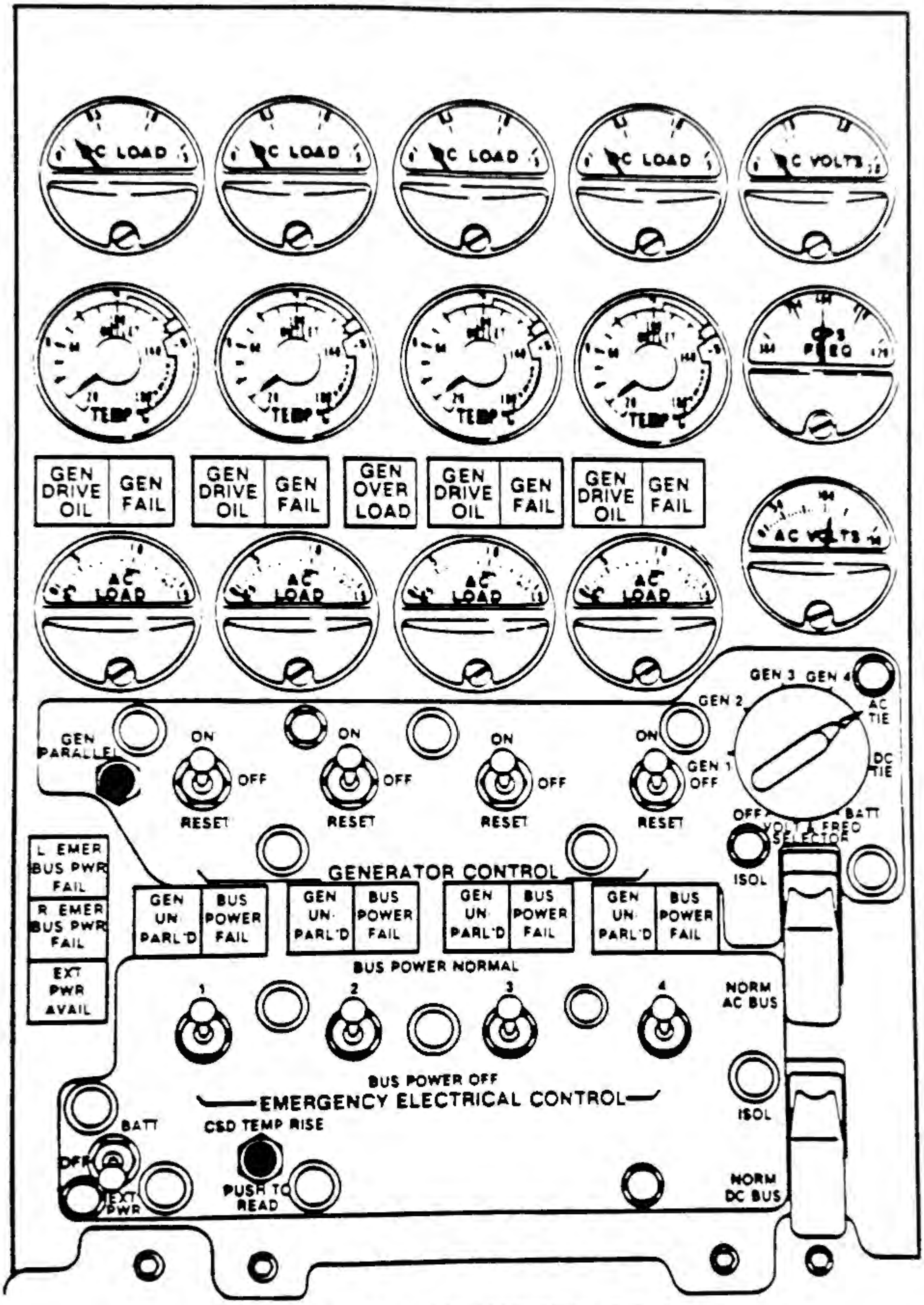

FREQUENCY AND LOAD CONTROL PANELS FOR
NO. 1 GENERATOR
NO. 2 GENERATOR
NO. 3 GENERATOR
NO. 4 GENERATOR
AC SYSTEM BUS PROTECTION PANEL
GND SERVICE FUSES
AUX. HYD. PUMP FUSES
VOLTAGE REGULATOR AND GENERATOR CONTROL PANELS FOR
NO. 4 GENERATOR
NO. 3 GENERATOR
NO. 2 GENERATOR
NO. 1 GENERATOR
NO. 1 EXTERNAL POWER RELAY

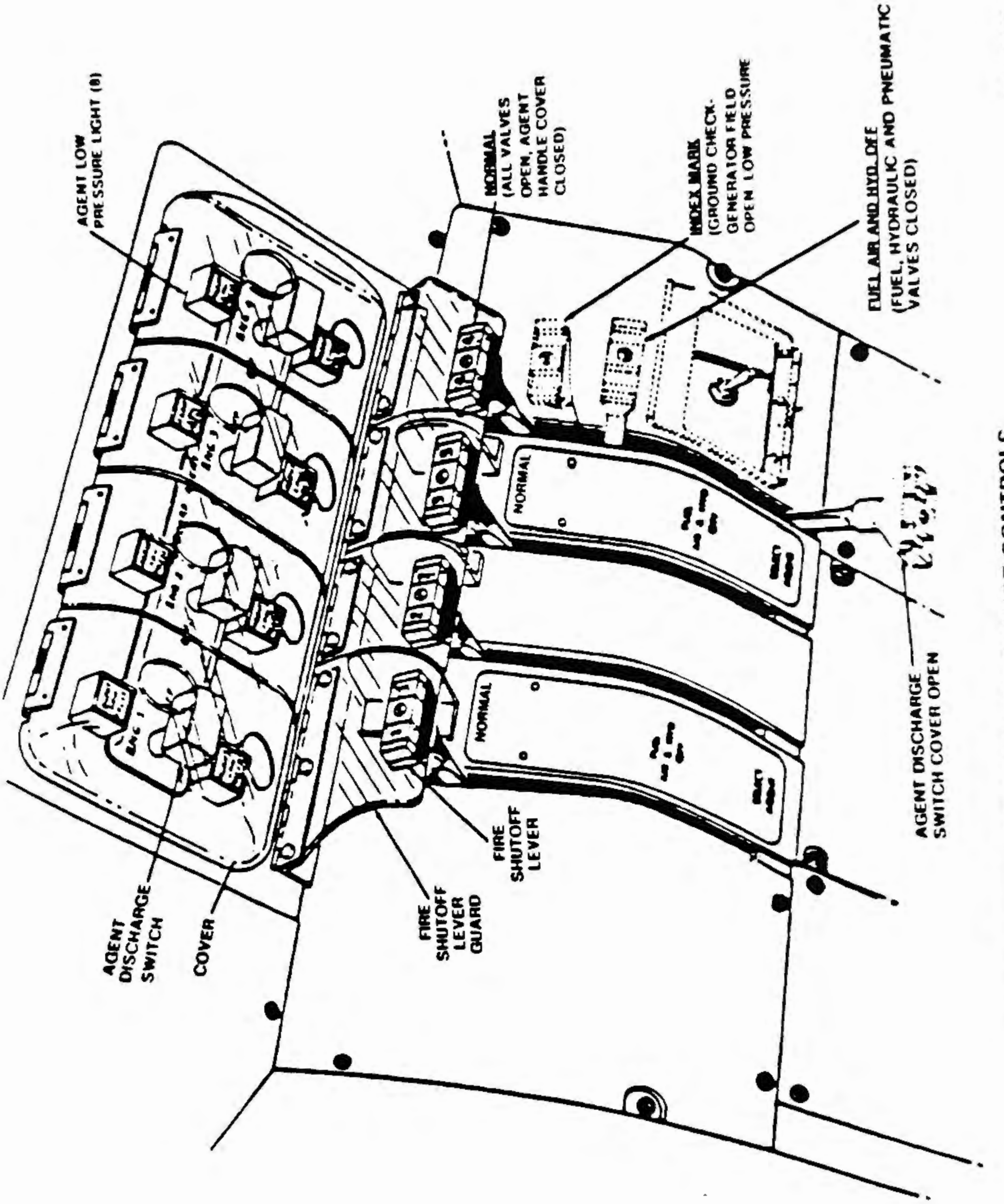
Figure 24-7



SYSTEM ENGINEER'S PANEL

FTX80011

Figure 24-8

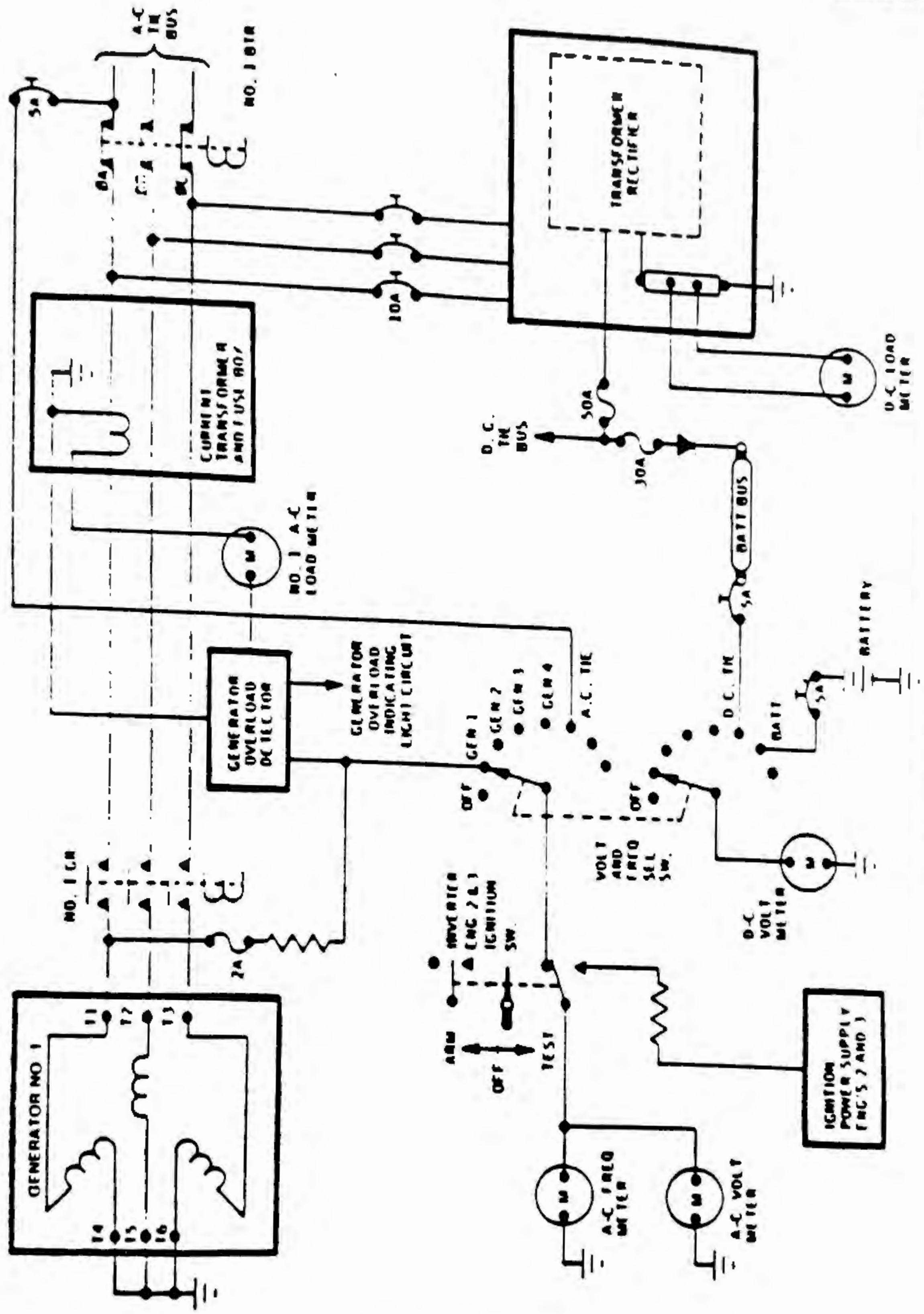

AGENT LOW PRESSURE LIGHT (8)
AGENT DISCHARGE SWITCH
COVER
FIRE SHUTOFF LEVER GUARD
FIRE SHUTOFF LEVER
NORMAL
NORMAL (ALL VALVES OPEN, AGENT HANDLE COVER CLOSED)
INDEX MARK (GROUND CHECK-GENERATOR FIELD OPEN LOW PRESSURE
FUEL AIR AND HYD. OFF (FUEL, HYDRAULIC AND PNEUMATIC VALVES CLOSED)
AGENT DISCHARGE SWITCH COVER OPEN

FIRE SHUTOFF AND AGENT DISCHARGE CONTROLS

FTX80008

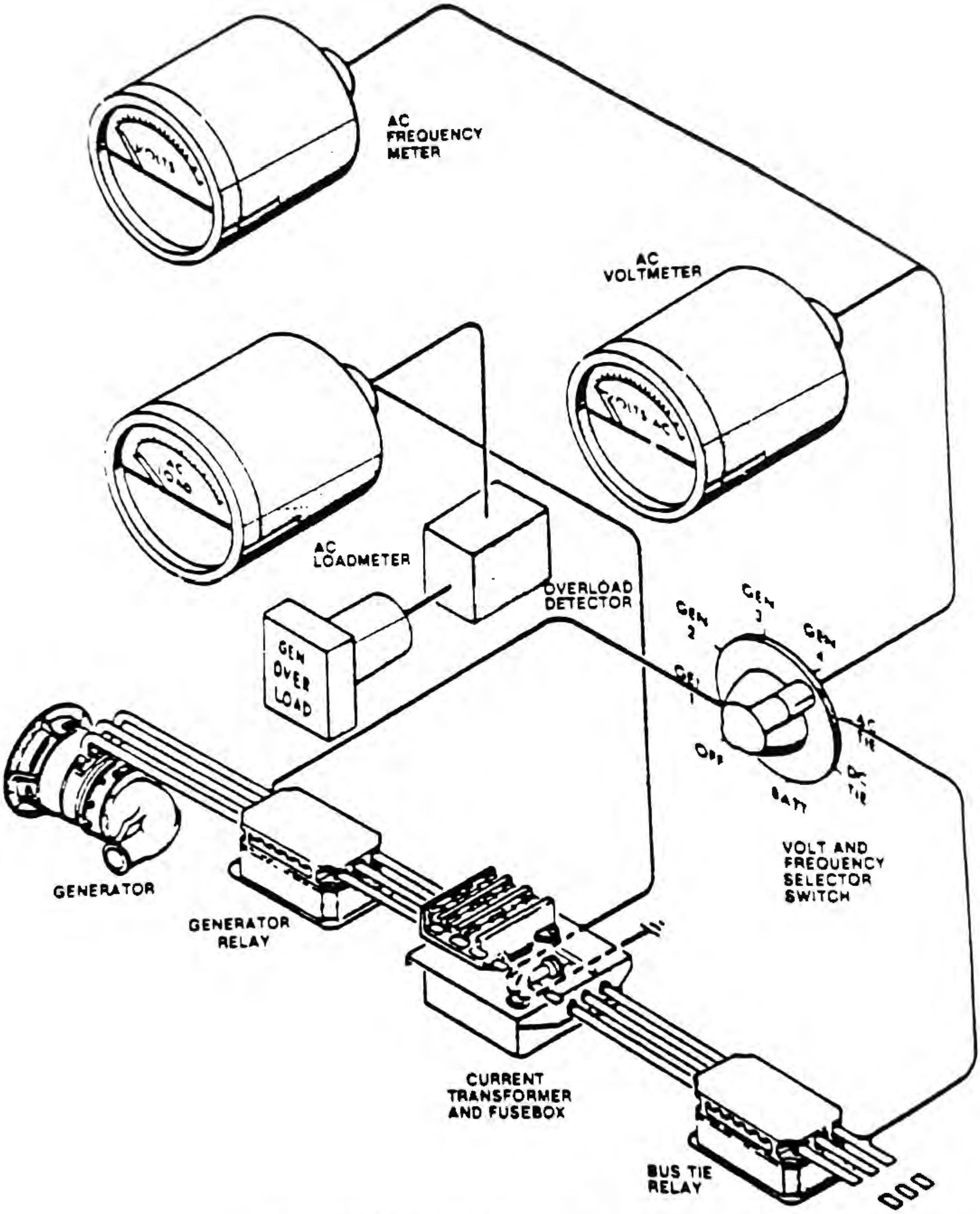
Figure 24-9

FTX80009



AC AND DC MONITORING INSTRUMENTATION

Figure 24-10



GENERATOR INDICATION-FUNCTIONAL

FTX80010

Figure 24-11

C. Electrical Power Limitations

(1) The values shown in the normal column are normal operating ranges. Indications outside the normal range indicate possible system abnormalities.

(2) Limits shown in the allowable column should not be exceeded, and sustained operation at these limits is not recommended.

CAUTION: DAMAGE TO ELECTRICAL EQUIPMENT OF THE AIRPLANE IS POSSIBLE IF AC ELECTRICAL SYSTEMS HAVE BEEN SUBJECTED TO VOLTAGES HIGHER THAN 130 VOLTS, PHASE-TO-NEUTRAL, OR 225 VOLTS, PHASE-TO-PHASE, DUE TO MISADJUSTMENT OF EXTERNAL POWER SUPPLY. ANY AC OVERVOLTAGE APPLIED TO TRANSFORMER-RECTIFIERS WILL RESULT IN DC OVERVOLTAGE BEING APPLIED TO DC EQUIPMENT. ALL ELECTRICAL, NAVIGATIONAL, RADIO, AND RADAR EQUIPMENT SUBJECTED TO DAMAGING OVERVOLTAGES SHOULD BE INSPECTED AND FUNCTIONALLY CHECKED ACCORDING TO APPLICABLE MAINTENANCE PRACTICES.

CAUTION: ANY CONDITION THAT CAUSES ANY INDICATION IN ALLOWABLE COLUMN, OTHER THAN WITHIN NORMAL RANGE, SHOULD BE CORRECTED AT EARLIEST OPPORTUNITY.

	Normal	Allowable	
	Min or Max	Min	Max
AC voltmeter (external power or generator operation)	112 to 118 volts	107 volts	123 volts
Frequency meter (external power on tie bus)	396 to 404 cps	380 cps	420 cps
Frequency meter (generator operation)	396 to 404 cps		
DC voltmeter (battery operation)	Not less than 24 volts		
DC voltmeter (external power or generator operation	25 to 29 volts		
AC loadmeter (paralleled flight operation)	With + -.1 of average load with total load not less than 2.0, as specified in Note 1	Zero	1.37
AC loadmeter (unparalleled, flight operation)	Over zero and under 1.37	Zero	1.37
AC loadmeter (paralleled, ground operation, see Note 2)	Within + 0.1 of average load with total load not less than 2.0, as specified in Note 1	Zero	1.0
AC loadmeter (unparalleled, ground operation, see Note 2)	Over zero and under 1.0	Zero	1.0

	Normal Min or Max	Allowable Min	Max
Generator overload light (ground operation)	Light should come on between loadmeter indication of 0.94 and 1.0		
Generator overload light (flight operation)	Light should come on between loadmeter indication of 1.29 and 1.37		
DC loadmeter	Maximum difference between any two indicators should not exceed 0.6, and all indicators should indicate some load		
CSD transmission oil temperature rise	Zero to 11°C		17°C
CSD transmission outlet oil temperature	20° to 132°C		146°C

NOTE: Average load is related only to generators in parallel and equals the total of associated loadmeter readings divided by the number of generators in parallel

NOTE: Generator overload ratings for short time operation are:

(a) 1.5 for 5 minutes

(b) Over 1.5 for 5 seconds (the overload rating of the generator is 2.0 for 5 seconds)

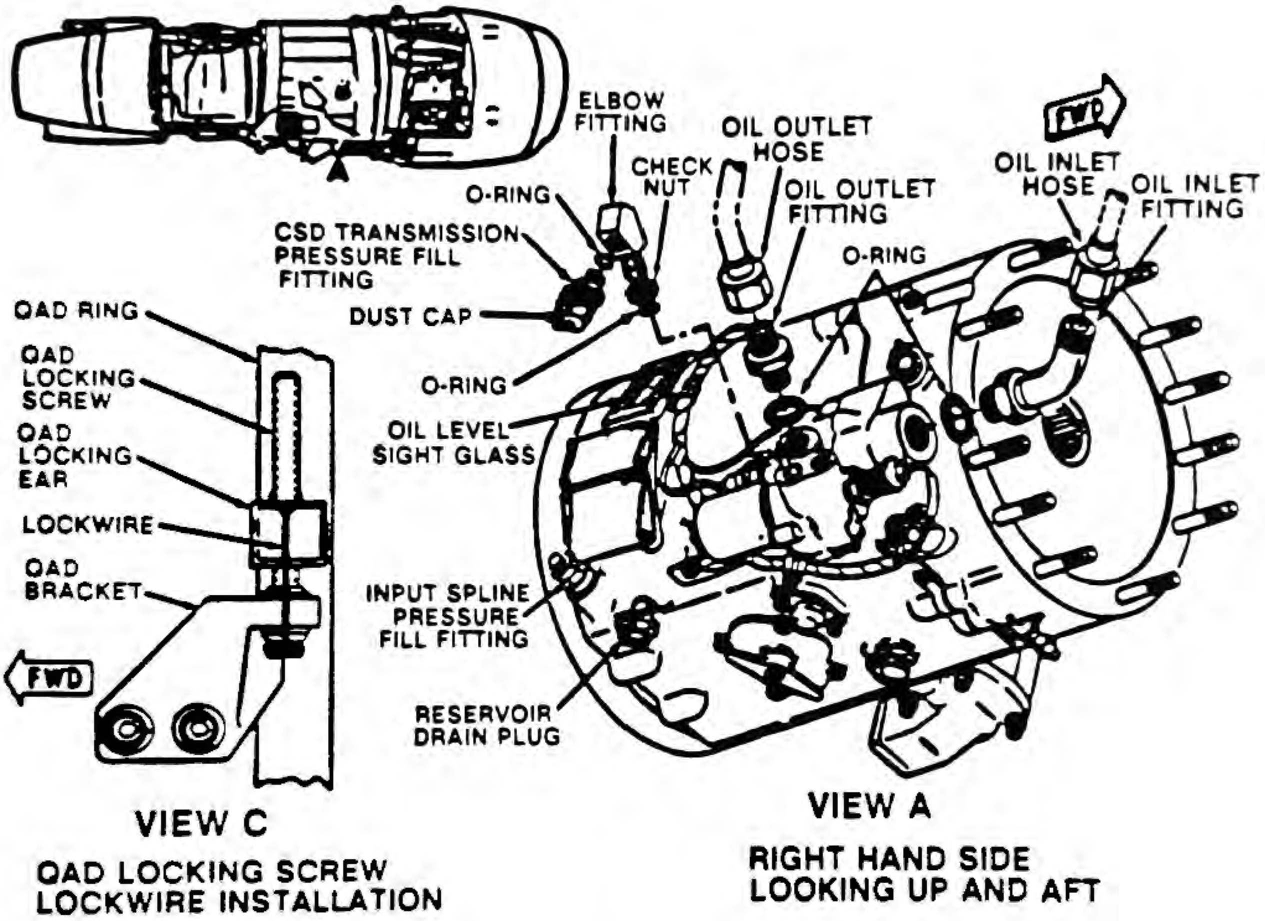
2. Generator Drive - Description and Operation

A. General

(1) A constant speed drive (CSD) transmission is installed on each engine to provide a means of driving an AC generator at a constant speed regardless of variations in engine operating speeds and applied electrical loads. The transmission is located on the forward section of the engine accessory drive case, at the lower centerline of the engine. A quick attach-detach (QAD) kit is used to secure the transmission to the engine accessory drive case (see Figure 24-12 and 24-13).

B. Description (See Figure 24-14)

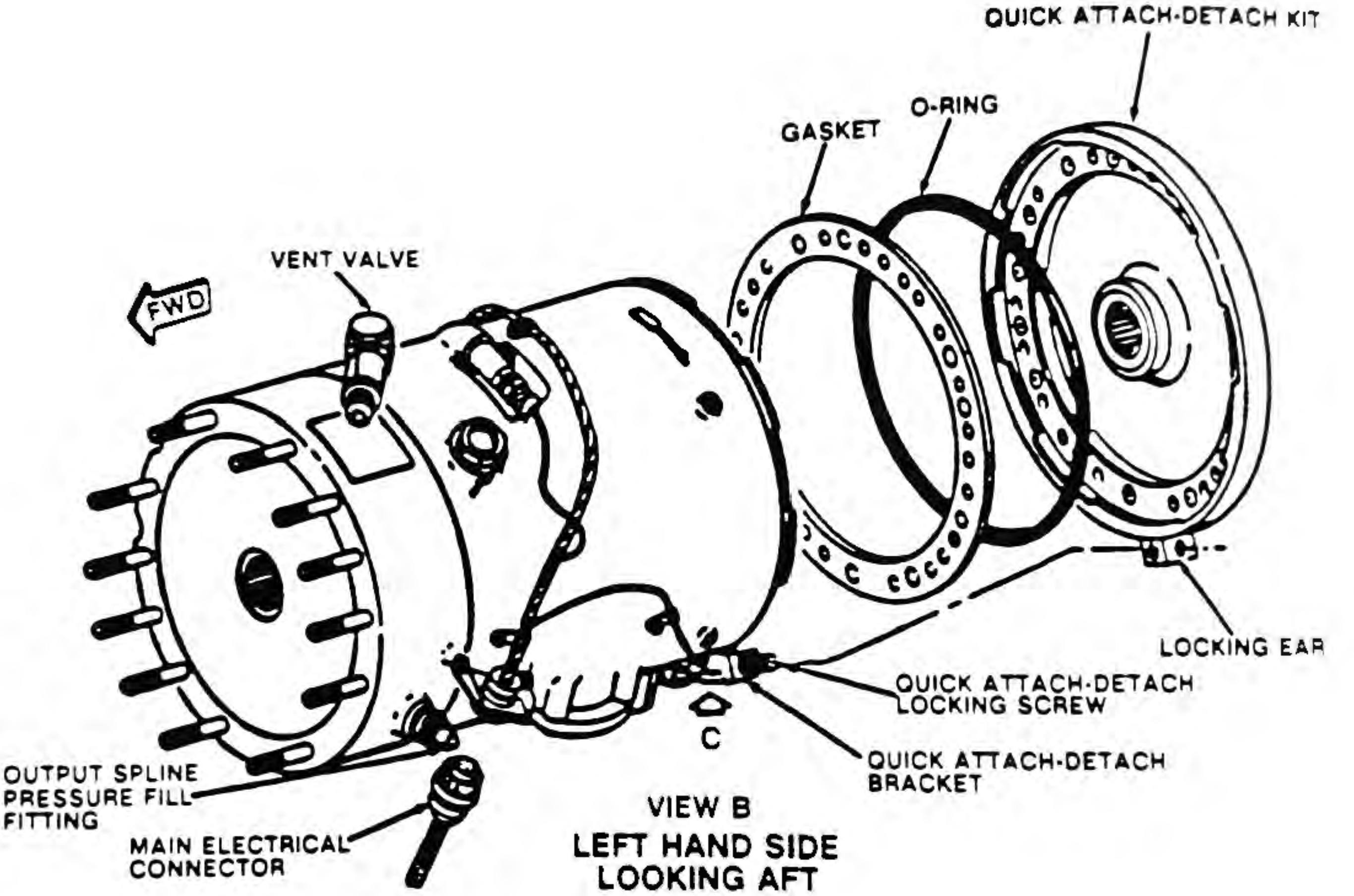
(1) The CSD transmission is a gear-differential type unit consisting of an hydraulic system with an integral oil reservoir, a power unit, and a governor. Reservoir oil is supplied to the hydraulic system charge pump and is pumped as charge pressure oil through a charge filter to the power unit and governor. The governor, a spring-biased, flyweight-operated, hydraulic-controlled valve, ports control pressure oil to the control cylinder or drains control pressure oil to the transmission sump. The control cylinder regulates the operation of the variable hydraulic unit within the power unit. Through the combined effects of the variable hydraulic unit, the gear differential, and the fixed hydraulic unit, the power unit is capable of adding to, or subtracting from, the input speed to maintain a constant output speed of 6000 rpm, within narrow limits. Drain oil, pumped from the transmission sump by the scavenge pump, and system oil, discharged from the charge relief valve, are returned to the reservoir through a scavenge filter and oil cooling system. The oil is cooled as it is pumped through the CSD oil cooler. The oil cooler is installed in the air inlet duct on the lower right side of the engine. Cooling air for the oil cooler is provided by ram air during flight and by the engine ground cooling and jet pump system during ground operations. The cooler consists of an all-welded core and a temperature regulating and pressure relief valve. Hot oil from the CSD transmission enters the cooler through the inlet valve. If the oil temperature is less than the thermostat set point, the oil flows directly to the outlet valve, through a bypass valve, without circulating through the oil cooler core. When the oil temperature is greater than the thermostat set point, the oil flows directly to the outlet valve, through a bypass valve, without circulating through the oil cooler core. When the oil temperature is greater



CONSTANT SPEED DRIVE TRANSMISSION

FTX8012A

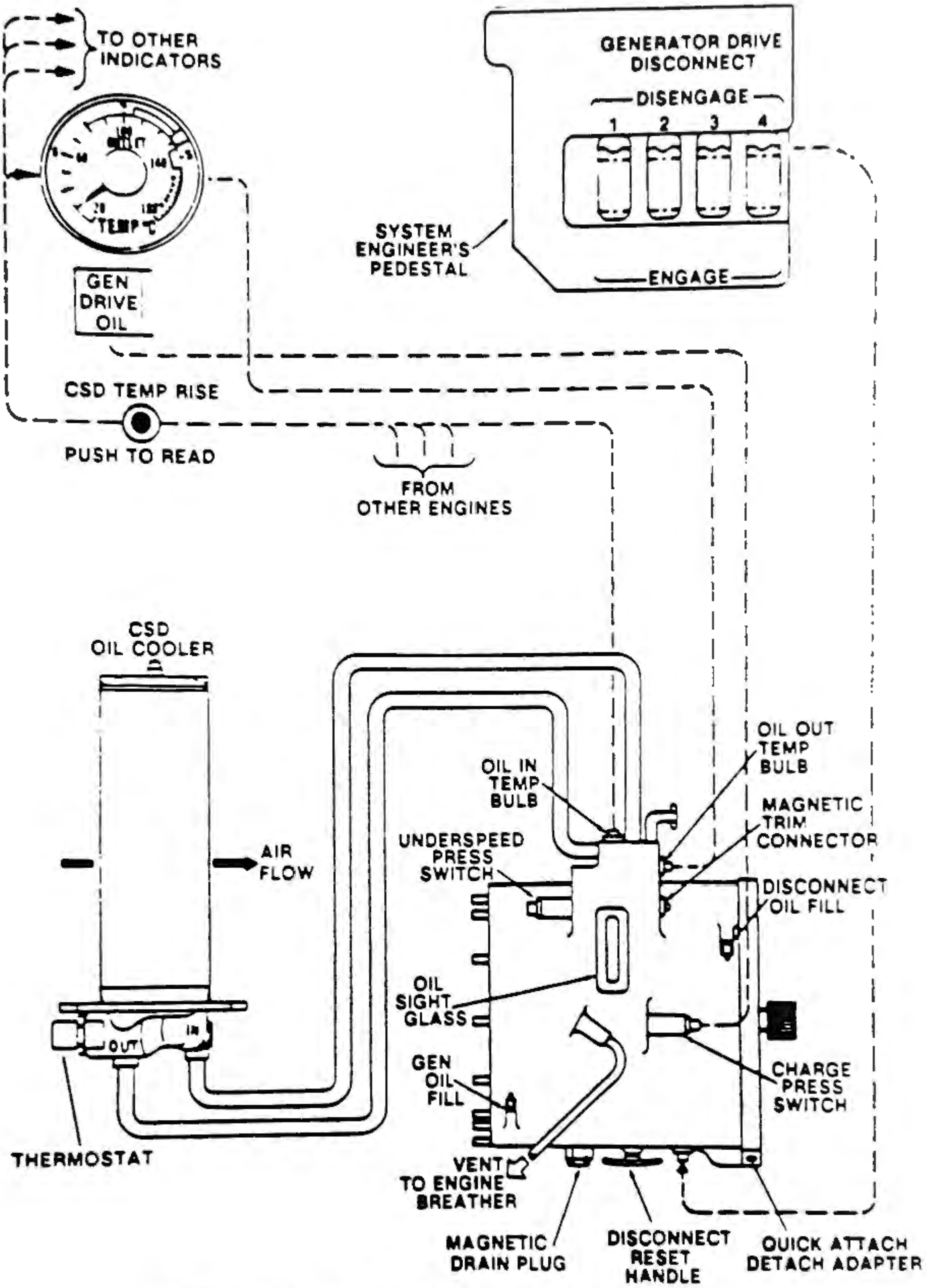
Figure 24-12


QUICK ATTACH-DETACH KIT
O-RING
GASKET
VENT VALVE
FWD
LOCKING EAR
QUICK ATTACH-DETACH LOCKING SCREW
C
QUICK ATTACH-DETACH BRACKET
OUTPUT SPLINE PRESSURE FILL FITTING
MAIN ELECTRICAL CONNECTOR
VIEW B
LEFT HAND SIDE
LOOKING AFT

CONSTANT SPEED DRIVE TRANSMISSION

FTX8012B

Figure 24-13



GENERATOR DRIVE SYSTEM - SCHEMATIC

FTX80013

Figure 24-14

than the thermostat set point, the thermostat sensing element expands and forces the poppet valve into the valve seat. This action closes the bypass valve and the oil is circulated through the core of the oil cooler. The cooled oil is then returned to the CSD transmission through the oil cooler outlet valve. The thermostat element is also sensitive to differential pressures which exist between the inlet and outlet valves. A pressure relief valve will begin to open at a differential pressure of 50 psi and will be fully opened at differential pressures exceeding 90 psi.

(2) Filling or adding oil to the CSD transmission is accomplished by connecting a pressure fill stand capable of delivering lubricating oil to a pressure fill fitting on the transmission case. Correct oil level is determined by observing a sight glass located on the right side of the CSD transmission case. Oil is added or drained according to specific maintenance procedures.

CAUTION: DO NOT OVERFILL. OVERHEATING AND OIL SLUDGING CAUSED BY OVERFILLING CAN RESULT IN DRIVE DAMAGE.

(3) To ensure lubricating for the CSD input and output spline shafts, the spline cavities are filled with enough oil to cover the splines. The pad cavity for the input spline is formed between the drive end of the CSD transmission and the engine gearbox mounting pad. The cavity for the ouput spline is formed between the CSD transmission and the drive end of the AC generator. The oil in the output spline cavity also lubricates the drive shaft, drive-end bearing, and the anti-drive-end bearing of the AC generator. Filling or adding oil to the cavities is accomplished by connecting a pressure-fill stand capable of delivering lubricating oil to the pressure-fill fittings on the CSD transmission case. Overfill drain fittings are provided to prevent overfilling.

(4) Transmission output rotation can be stopped, under specific procedures, by placing the corresponding CSD disconnect switch in the disconnect position. The electrically energized disconnect solenoid releases a spring-loaded pawl and the resultant action disengages the rotating input shaft from the planetary differential of the CSD transmission. When disengaged, a transmission must not be re-engaged until the engine is shut down and comes to a complete stop. Re-

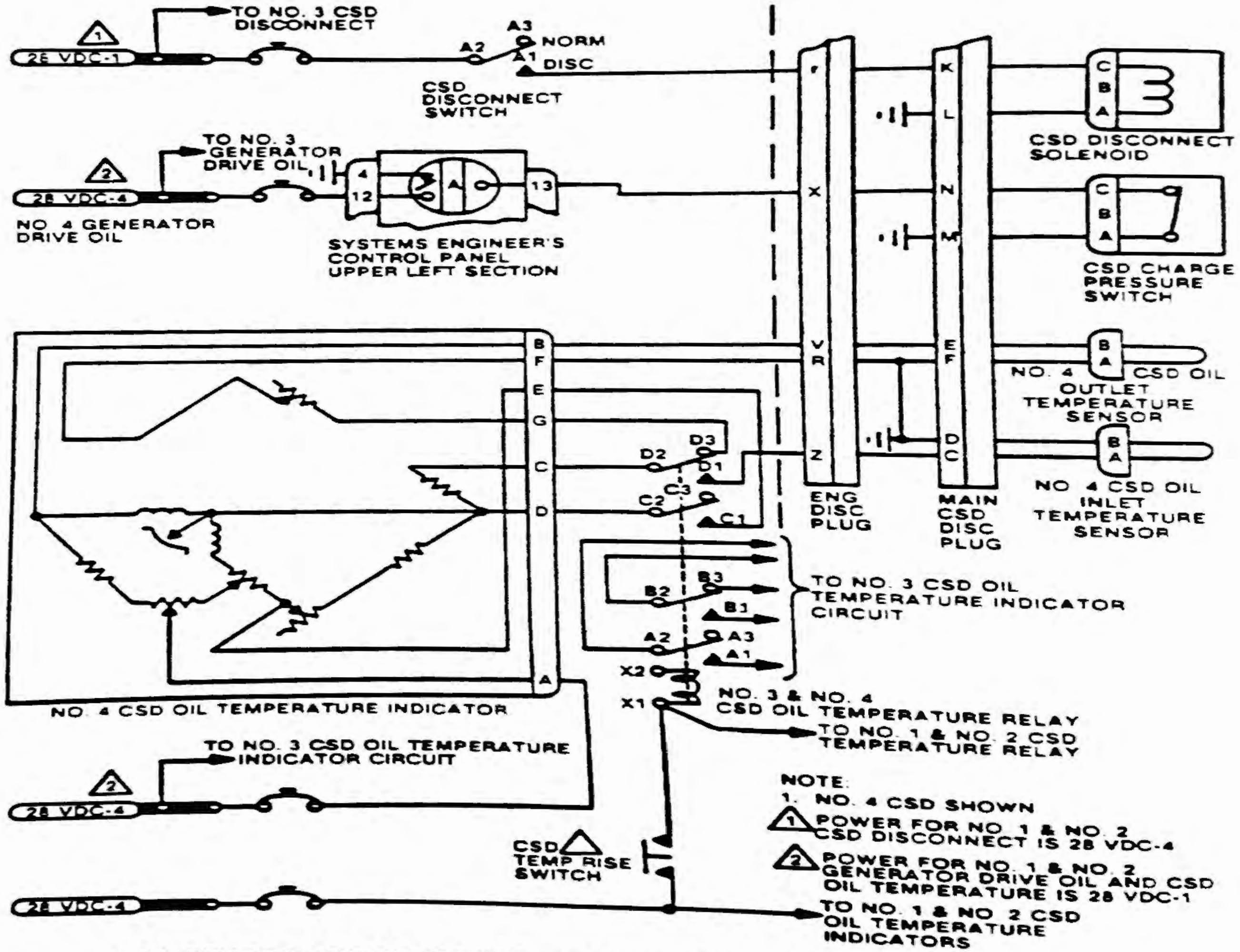
engagement of the transmission is accomplished by pulling downward on the disconnect reset handle, until a stop is felt, and then releasing the handle.

C. Control and Indications (See Figure 24-15)

(1) A charge pressure switch located at the top of each transmission and a caution light on the system engineer's control panel are used in the generator drive oil light circuitry. When the charge oil pressure is below a minimum safe value (100 to 150 psi), the charge pressure switch closes and completes the light ground circuit and the generator drive oil light comes on. During normal operation, charge pressure opens the contacts of the charge pressure switch and the generator drive oil light is off.

(2) CSD oil temperature is sensed by temperature sensors installed in the oil outlet and oil inlet ports of each CSD transmission. The corresponding CSD oil temperature indicators, located on the system engineer's control panel, display a continuous oil outlet temperature indication during normal operation. When a button-type switch, located on the systems engineer's control panel, is pressed; a momentary CSD differential temperature rise indication is displayed on the indicators. Differential temperature rise is the difference between oil outlet and oil inlet temperatures.

(3) An underspeed sensor, located on the CSD transmission case, is a part of the generator control circuit and is actuated by CSD internal oil pressure when the CSD transmission reaches the desired operating speed. The actuated underspeed sensor causes a generator relay to close and the corresponding generator is then connected to the airplane electrical systems. If an underspeed condition exists, or if an engine is being shut down, the underspeed sensor is deactuated. After a time delay, the generator relay opens, and the generator is removed from the airplane electrical systems. The underspeed sensor unit it a variable inductor, without any switch contacts. Under no circumstances should the sensor unit be "jumped" during engine/generator operation, as a major component in the voltage regulator-control panel would be exposed to high voltage, and consequently destroyed.


TO NO. 3 CSD DISCONNECT
1
28 VDC-1
A3
A2
NORM
A1
DISC
CSD DISCONNECT SWITCH
TO NO. 3 GENERATOR DRIVE OIL
2
28 VDC-4
NO. 4 GENERATOR DRIVE OIL
4
12
A
13
SYSTEMS ENGINEER'S CONTROL PANEL UPPER LEFT SECTION
F
X
V
R
Z
ENG DISC PLUG
K
L
N
M
E
F
D
C
MAIN CSD DISC PLUG
C
B
A
CSD DISCONNECT SOLENOID
C
B
A
CSD CHARGE PRESSURE SWITCH
B
A
NO. 4 CSD OIL OUTLET TEMPERATURE SENSOR
B
A
NO. 4 CSD OIL INLET TEMPERATURE SENSOR
B
F
E
G
C
D
A
NO. 4 CSD OIL TEMPERATURE INDICATOR
D3
D2
D1
C3
C2
C1
B3
B2
B1
A3
A2
A1
X2
X1
TO NO. 3 CSD OIL TEMPERATURE INDICATOR CIRCUIT
NO. 3 & NO. 4 CSD OIL TEMPERATURE RELAY
TO NO. 1 & NO. 2 CSD TEMPERATURE RELAY
TO NO. 3 CSD OIL TEMPERATURE INDICATOR CIRCUIT
2
28 VDC-4
CSD TEMP RISE SWITCH
28 VDC-4
TO NO. 1 & NO. 2 CSD OIL TEMPERATURE INDICATORS

NOTE:
1. NO. 4 CSD SHOWN
1 POWER FOR NO. 1 & NO. 2 CSD DISCONNECT IS 28 VDC-4
2 POWER FOR NO. 1 & NO. 2 GENERATOR DRIVE OIL AND CSD OIL TEMPERATURE IS 28 VDC-1

CONSTANT SPEED DRIVE INDICATIONS AND DISCONNECT CIRCUITS -- SIMPLIFIED

FTX80014

Figure 24-15

(4) Frequency and Load Control Panels

(a) Four frequency and load control panels, one for each generator drive system, are located on the EPC generator control rack. The panels maintain an equal electrical load distribution among the operating AC generators.

(b) Equal load distribution is maintained by the load division circuit within the panel. The circuit monitors and compares the load on the corresponding generator with the average load of all generators operating in parallel. If a generator is assuming more or less than the average load, the control panel transmits a corrective signal to the corresponding CSD transmission magnetic trim head and the CSD output speed is increased or decreased accordingly.

3. Constant Speed Drive Transmission - Description and Operation

A. Description

(1) The constant speed drive (CSD) transmission is a gear differential-type unit installed on the forward section of the engine accessory drive case at the lower centerline of the engine. There is one CSD transmission and AC generator combination for each of the four engines. The CSD transmission consists essentially of a power unit, hydraulic unit, an all-attitude reservoir, a governing system, and an electrical disconnect. Regardless of the variation in engine operating speeds and applied electrical loads, the CSD transmission provides a means of driving an AC generator at a constant speed of 6000 rpm, within narrow limits. Although the speed of the CSD transmission input shaft can vary, the speed of the output shaft remains constant and the generator output is controlled at a frequency of 400 (± 4) cps. If the load on one generator increases or decreases in relation to the loads on the other generators, the load control panel load division circuit directs an impulse to the CSD governor to increase or decrease the CSD output power. The governor maintains constant output speed of the CSD transmission through the overdrive, straight-through drive, and underdrive phases of operation.

(2) Overdrive (See Figure 24-16)

If the input speed supplied to the CSD transmission is lower than that needed to produce the required output speed, the CSD transmission will add the necessary speed hydraulically to the speed of the engine gearbox through the differential, and thus maintain constant output speed. The CSD transmission, when adding speed hydraulically, is operating in overdrive.

(3) Straight-Through Drive

If the input speed supplied to the CSD transmission is sufficient to produce the required output speed, the CSD transmission drives the AC generator directly through the differential. The CSD transmission, when neither adding nor subtracting speed hydraulically, is operating in straight-through drive.

(4) Underdrive (See Figure 24-17)

If the input speed supplied to the CSD transmission exceeds that needed to produce the required output speed, the CSD transmission subtracts the necessary speed hydraulically from the speed of the engine gearbox through the differential, and thus maintains constant output speed. The CSD transmission, when subtracting speed hydraulically, is operating in underdrive.

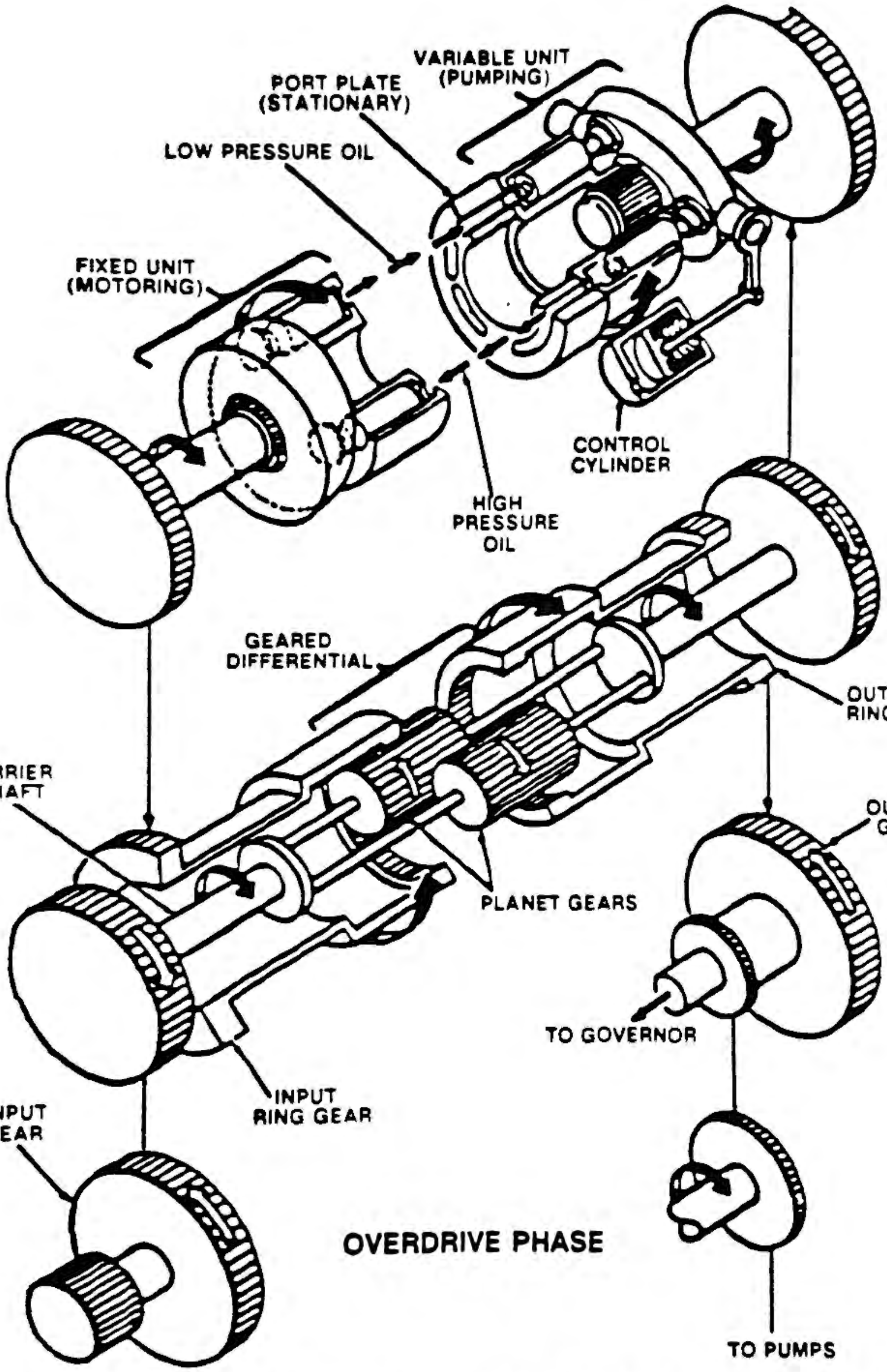
B. Operation

(1) Power Unit

(a) The power used to drive the AC generator is controlled and transmitted from the engine through the combined effects of the gear differential, the variable hydraulic unit, and the fixed hydraulic unit.

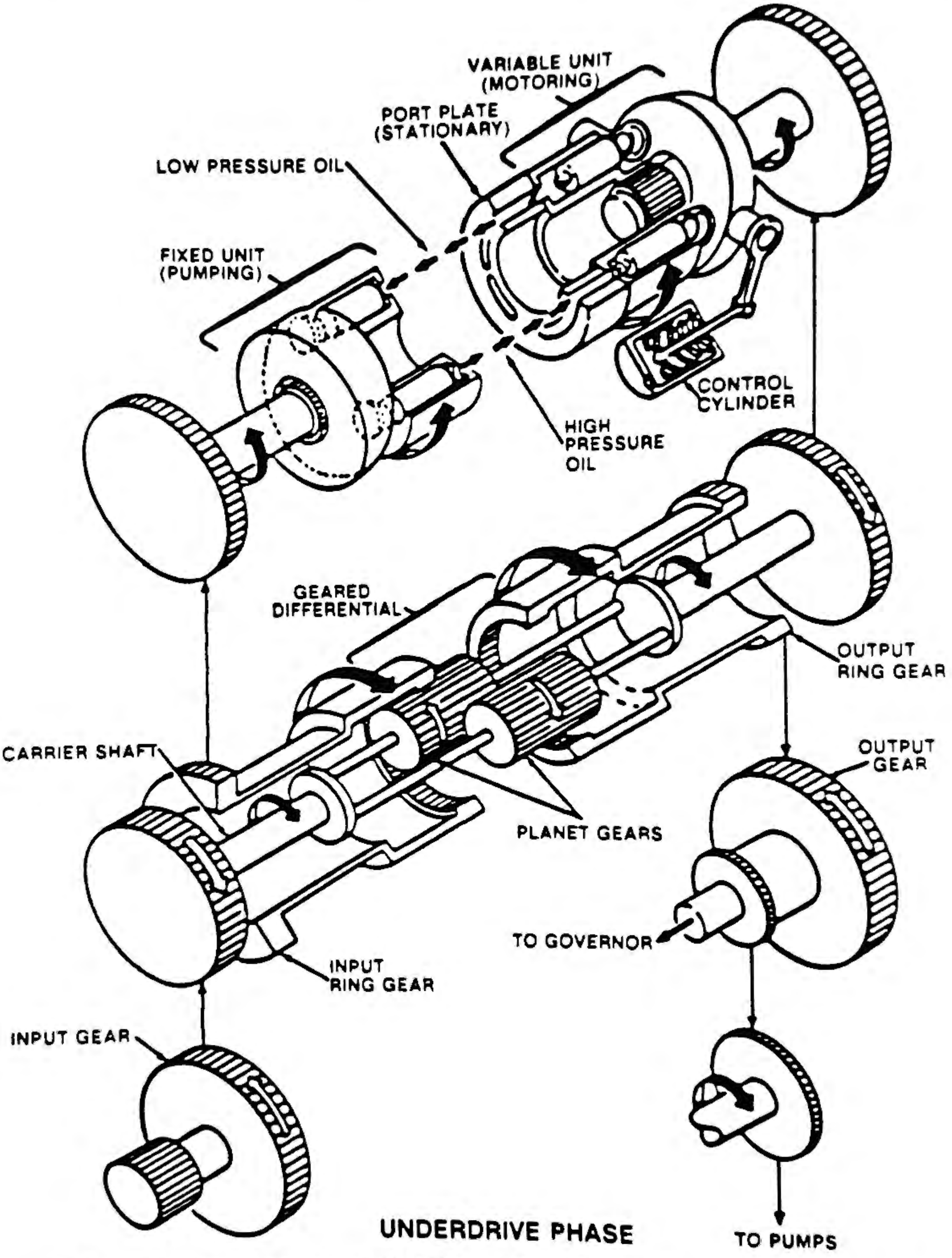
(b) Geared Differential

1 The geared differential consists of a carrier shaft, two planet gears, an input ring gear, and an output ring gear. The ratio between the ring gears and the carrier shaft is 2:1.



CSD TRANSMISSION POWER UNIT FUNCTIONAL OPERATION FTX80015

Figure 24-16



UNDERDRIVE PHASE

CSD TRANSMISSION POWER UNIT FUNCTIONAL OPERATION

FTX80016

Figure 24-17

2 At any speed and load condition, a torque load is imposed on the output ring gear by the output gear. Input torque is supplied by the input gear turning the carrier shaft. If there were no torque on the input ring gear, it would run freely at whatever speed would allow the output ring gear to stop Because the carrier shaft to ring gear ratio is 2:1, the speed of the input ring gear at this condition would be double that of the carrier shaft. Since a given output speed is desired, the input ring gear must be constrained.

2 If the input ring gear is constrained to zero speed, the output ring gear will run at double the carrier shaft speed. If the input ring gear is forced to rotate in a direction opposite to that of the carrier shaft, the output ring gear will run at a speed more than double that of the carrier shaft. If the input ring gear is allowed to rotate in the same direction as the carrier shaft, the output ring gear will run at a speed less than twice that of the carrier shaft. Thus, the differential is a speed- summing or speed-adding device which is controlled through the input ring gear to add to or subtract from the speed of the engine gearbox to achieve the desired output.

(c) Variable Hydraulic Unit

1 The variable hydraulic unit consists of a cylinder block, reciprocating pistons, a variable angle wobbler, and a control piston. The variable unit is connected to the engine accessory pad by direct gearing; consequently, the speed of the cylinder block is always proportional to the input speed and the direction of rotation is always the same.

2 When the CSD transmission is operating in overdrive, the variable hydraulic unit functions as a hydraulic pump. To enable the variable unit to pump oil, the governor ports charge oil to the control piston which positions the wobbler so that oil is compressed as the pistons are forced into the rotating cylinder block. This high-pressure (working pressure) oil is ported to the fixed hydraulic unit.

3 As the input speed increases and the need to add speed decreases, the governor ports less oil to the control cylinder until the variable wobbler is in a position approximately

(3) All-Attitude Reservoir (See Figure 24-19)

(e) General

The all-attitude reservoir is designed to separate entrained air from the system oil and provide a supply of de-aerated oil to the CSD transmission through a wide range of acceleration loadings and airplane attitudes. The reservoir contains no moving parts and performs its functions automatically, utilizing the energy of the CSD transmission scavenge oil.

(f) Swirl Chamber

Scavenge oil pumped through the CSD air/oil cooler returns to the CSD transmission reservoir via the swirl chamber. This return oil, which is highly aerated, enters the swirl chamber at high velocity through a tangential inlet, causing a swirling action which creates a vortex within the swirl chamber. Air entrained in the entering oil, having a lower density than the oil, moves to the center of the vortex and escapes to the upper chamber of the reservoir. The oil, relieved of the entrained air, moves along the wall of the swirl chamber and out into the lower chamber of the reservoir.

(g) Reservoir

1 Return oil is always de-aerated and ported to the lower reservoir chamber regardless of CSD transmission attitude. The inlet suction port is located approximately in the middle of the lower chamber; and the volume of oil delivered to the chamber is such that, regardless of CSD transmission attitude, the inlet port will always be surrounded by oil. Static pressure in the chamber is relatively low due to the constant removal of oil through the inlet suction port.

2 Regardless of CSD transmission attitude, the upper reservoir chamber will always receive a mixture of air and oil, or foam, or mist. As the air settles out of this mixture, the oil drains back into the lower reservoir chamber through small holes in the baffle between the upper and lower reservoir chambers. Residual air in the oil in the lower chamber also settles and

perpendicular to the pistons; and no oil, except that required for power losses due to friction and leakage, is pumped or received by the variable unit. At this time, the CSD transmission is operating in straight-through drive.

4 When the CSD transmission is operating in underdrive, the variable hydraulic unit functions as a motor. To enable the variable unit to operate as a motor (receive oil from the pumping unit), the governor ports oil away from the control cylinder causing the wobbler to be positioned so that the volume for accommodating oil in the piston bores on the high-pressure side is increased; consequently, oil flows from the fixed hydraulic unit to the variable unit.

(d) Fixed Hydraulic Unit

1 The fixed hydraulic unit consists of a cylinder block, reciprocating pistons, and a fixed angle wobbler. The direction of rotation and speed of the fixed hydraulic unit is determined by the volume of oil pumped or received by the variable hydraulic unit. This volume of oil is determined by the angular position of the variable wobbler and the speed of the rotating cylinder block.

2 When the CSD transmission is operating in overdrive, the fixed hydraulic unit functions as a hydraulic motor. High-pressure oil pumped from the variable unit forces the fixed unit pistons to slide down the inclined wobbler face, causing the cylinder block to rotate. The block's rotation forces the input ring gear on the differential to turn in a direction opposite to the carrier shaft rotation and adds to the speed of the engine gearbox through the differential, maintaining constant output speed.

3 As the input speed increases and the need to add speed to the output decreases, the variable hydraulic unit pumps less oil to the fixed hydraulic unit until the cylinder block stops rotating. At this time the CSD transmission is operating in straight-through drive.

4 When the CSD transmission is operating in underdrive, the fixed hydraulic unit functions as a pump. The variable wobbler in the variable hydraulic unit is positioned so that the variable hydraulic unit can receive oil from the fixed hydraulic unit. The fixed hydraulic unit's pistons are forced into the cylinder block as they slide up the inclined wobbler face, pumping high-pressure oil to the variable hydraulic unit and allowing the cylinder block to rotate in the direction opposite to that of overdrive operation. Opposite rotation of the cylinder block allows the input ring gear to turn in the same direction as the carrier shaft rotation and subtracts speed from the speed of the engine gearbox through the differential, maintaining constant output speed.

(2) Governing System

(a) The basic governor is a spring-biased, flyweight-operated, hydraulic control valve. The governor functions to control porting of CSD transmission charge oil to the control cylinder. The rotating sleeve in the governor is driven by the output gear and hence is responsive to CSD transmission output speed. Flyweights pivoted on this sleeve move a valve stem, located within the sleeve, against the bias of a spring. The inlet port directs charge oil to the valve stem groove between two lands. Depending on valve stem position, oil is either ported to the control piston or drained to the CSD transmission case.

(b) A magnetic trim device is included with the basic governor to apply the corrective signals from the frequency and load control panel. The trim device consists of permanent magnetic flyweights and an electromagnet located above the rotating tips of the flyweights. By passing a controlled DC electric current through the magnetic coil, a radial magnetic field is established between the concentric annular pole pieces. The magnetic field's direction is dictated by the polarity of the DC current. The rotating, permanent magnet flyweights have their magnetic axis oriented essentially at right angles to the radial magnetic field produced by the electromagnet. The two fields intersect and produce a controllable torque about the flyweight axis. This magnetically produced torque then works in conjunction with the centrifugal torque to apply a reaction on the stem. The magnetic trim provides a means of introducing electrical trimming signals to the transmission without any additional parts other than those already in the governor.

(3) Hydraulic System

(a) The hydraulic system consists of the charge pump, the scavenge pump, and the charge relief valve.

(b) Charge Pump

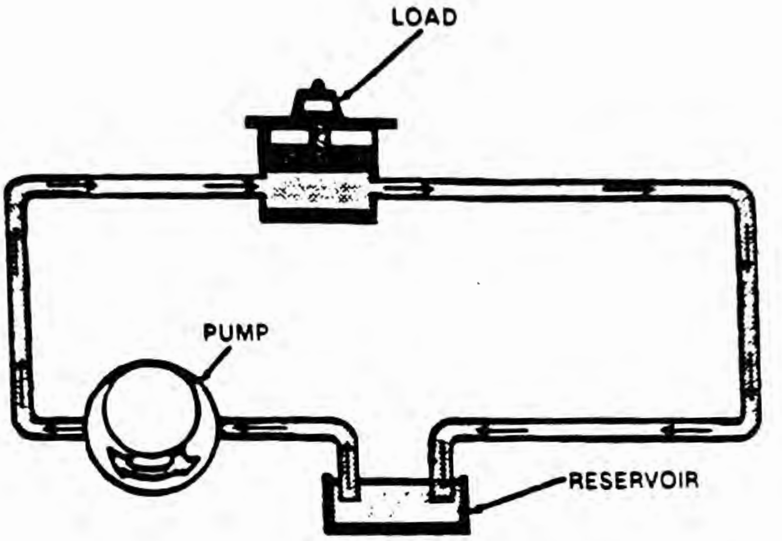
The charge pump is located in the hydraulic system between the all-attitude reservoir and the CSD transmission. The charge pump supplies oil to the cylinder blocks, governor, control piston, and the lubricating system.

(c) Scavenge Pump

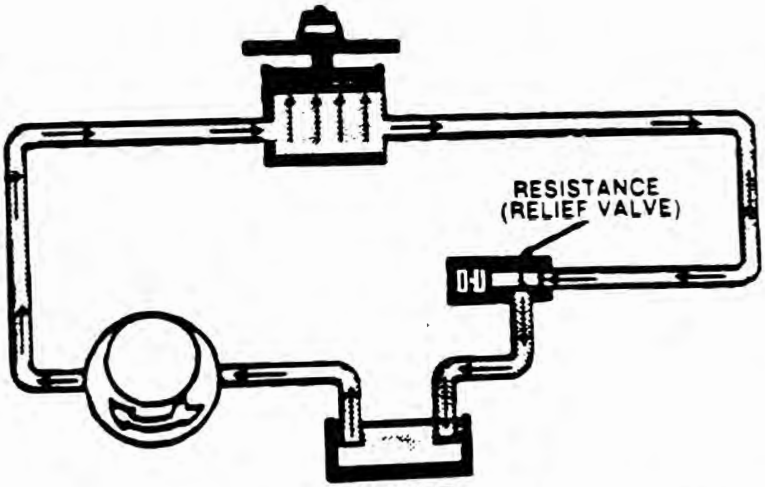
The scavenge pump is located in the hydraulic system between the CSD transmission sump and the CSD air/oil cooler. The scavenge pump picks up lube oil and internal leakage and pumps it through the CSD air/oil cooler into the all-attitude reservoir.

(d) Charge Relief Valve (See Figure 24-18)

The purpose of the charge relief valve is to regulate the operating pressure of the charge oil system. The valve accomplishes this function by metering the discharge of oil from the charge oil system to maintain the preset charge pressure. This principle is illustrated in Figure 24-18. A simple hydraulic system is shown in view A. The pump draws oil from the reservoir and delivers a constant volume of oil to the cylinder. The oil emerges from the right side of the cylinder without raising the load and flows back to the reservoir. The working pressure developed in this hydraulic system is negligible. As illustrated in view B, resistance has been added in the form of a relief valve at a point below the area where work is to be done. Pressure develops between the pump and relief valve which depends on the relief setting of the valve. assuming that the capacity of the pump relief setting of the valve, assuming that the capacity of the pump is adequate. This working pressure is used to raise the load. The same principle is used in the CSD transmission hydraulic system.



VIEW A
HYDRAULIC SYSTEM WITH NO RESISTANCE
IN THE LINE-NO WORK ACCOMPLISHED

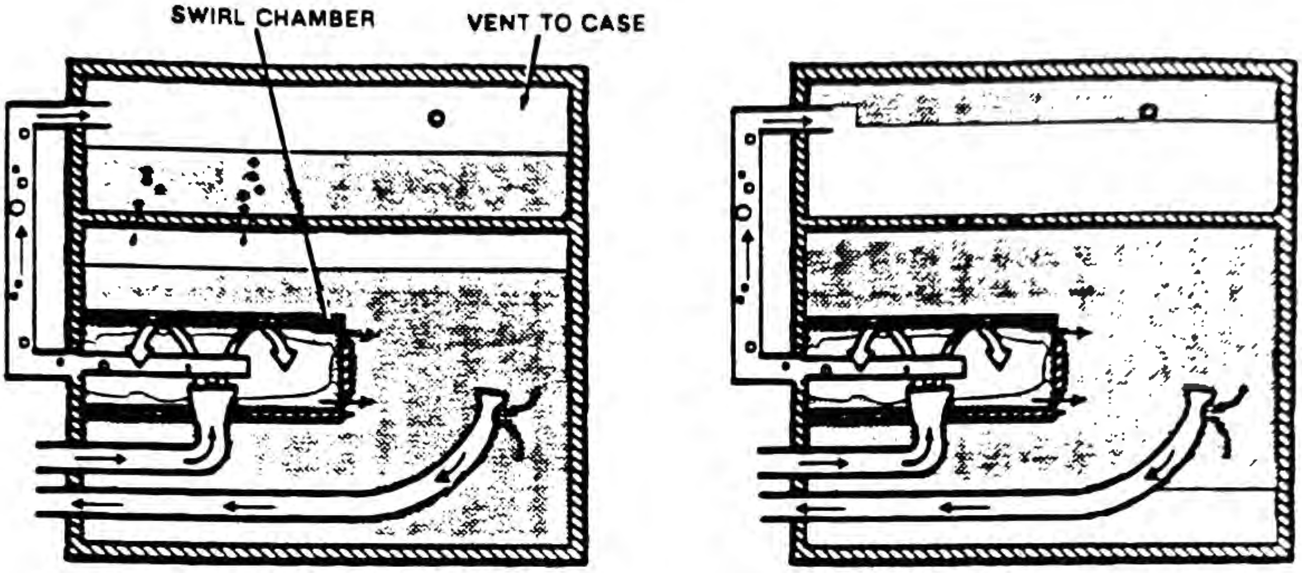


VIEW B
HYDRAULIC SYSTEM WITH RESISTANCE
IN THE LINE-LOAD IS RAISED

CHARGE RELIEF VALVE--FUNCTIONAL DIAGRAM

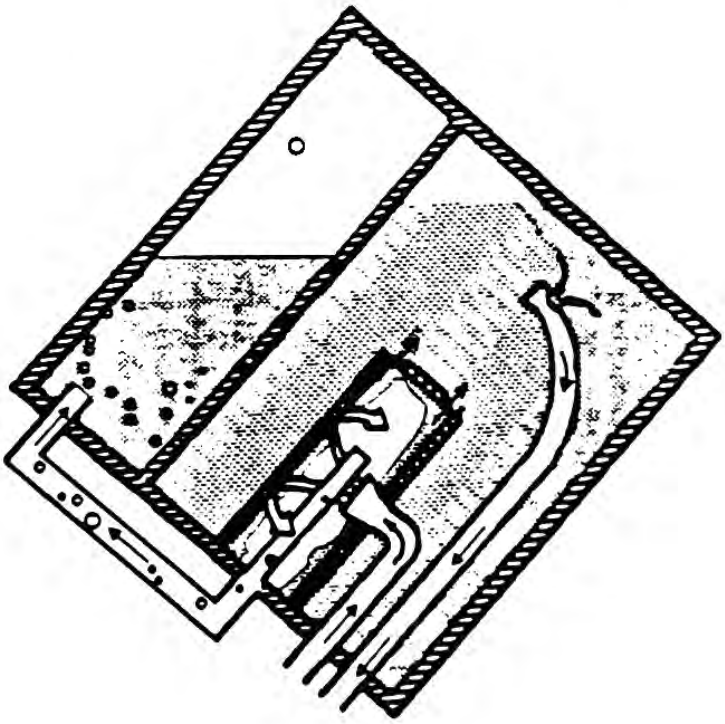
FTX80017

Figure 24-18



NORMAL ATTITUDE

NEGATIVE "G" CONDITION



45° TILT

ALL-ATTITUDE RESERVOIR

FTX80028

Figure 24-19

enters the upper chamber through these same holes. A vent between the upper chamber and the CSD transmission case equalizes reservoir and case pressures.

(4) Filters - Pressure Differential Indicators

Each filter (charge and scavenge) may have a pot-out button which actuates when the pressure drop across the filter is 44 psi, indicating that the filter is becoming clogged. The charge filter is also equipped with a bypass around the filter element to ensure a flow of oil if the element becomes completely clogged.

(5) Electrical Disconnect (See Figure 24-20)

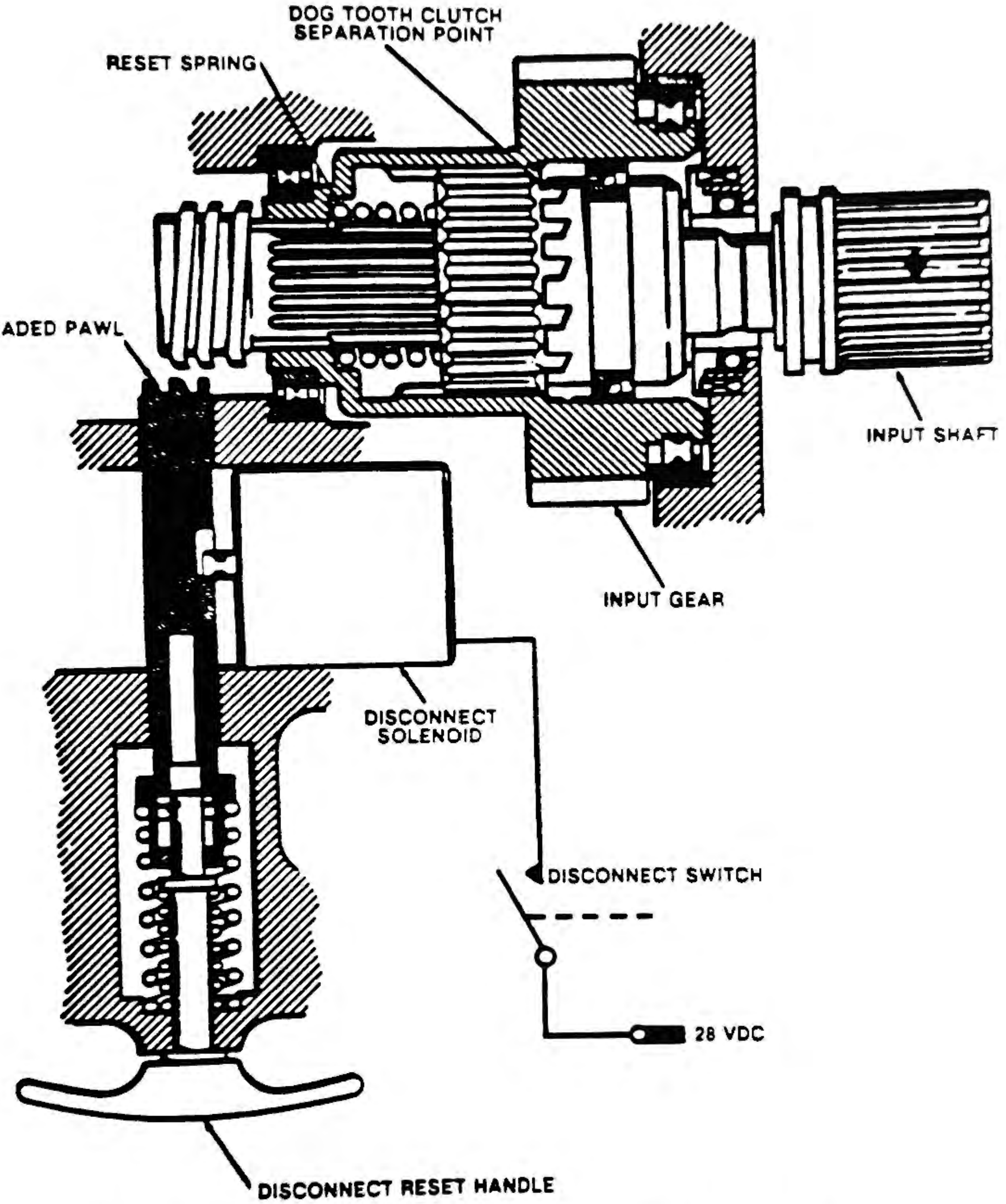
The CSD transmission disconnect is an electrically actuated device which decouples the input shaft from the spline shaft in the event of a CSD transmission malfunction. When the disconnect solenoid is energized by operation of the CSD disconnect switch, a spring-loaded pawl moves into contact with threads on the input shaft. The input shaft becomes a screw in a threaded hole, and input rotation causes the input shaft to move away from the input spline shaft, separating the driving dogs on the two shafts. When the driving dogs have been separated, the input spline shaft, which is still being driven by the airplane engine, spins freely in the CSD transmission without causing transmission rotation. Reset may be accomplished, following engine shutdown, by pulling down on the disconnect reset handle until the solenoid nose pin snaps into position.

4. AC Generation - Description and Operation

A. General (See Figure 24-21)

(1) Distribution of ac power from the generator to the loads is basically the same in each of the four generator systems. Each generator is connected to an ac generator bus through a generator relay, and the four ac generator buses are interconnected by corresponding bus tie relays through the ac tie bus. Each generator supplies power through a load monitoring relay to a corresponding ac load bus.

(2) The generator fuses consist of a set of feeder leads connected between the generator relay and the bus tie relay. The leads also supply power from the bus tie relay to the fuse terminals mounted on the face of the



CSD TRANSMISSION DISCONNECT MECHANISM

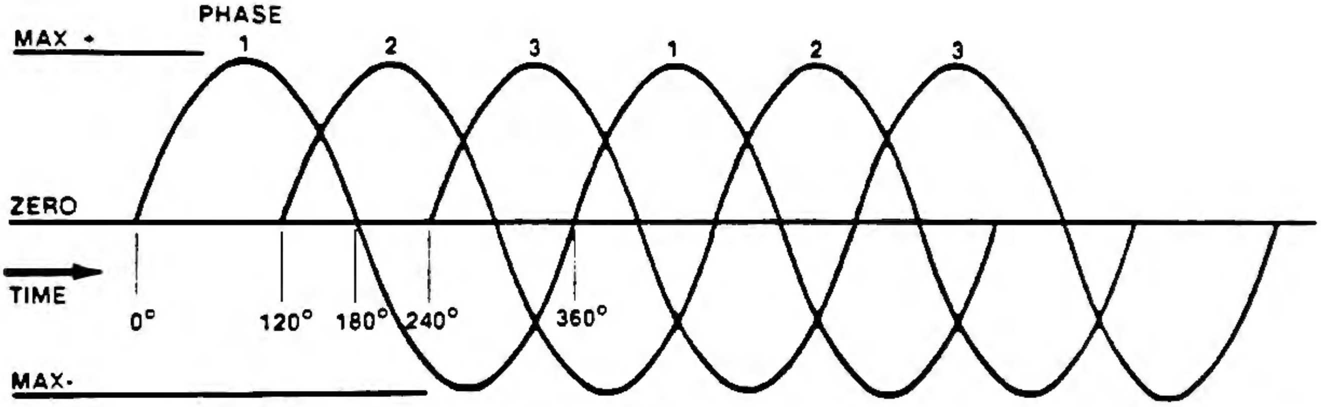
FTX80018

Figure 24-20

C. Phase

(1) The term "phase" indicates the number of alternating currents being carried simultaneously by the same circuit. "Degrees of phase" is used to designate the cyclic difference between the multi-currents in one circuit, as discussed below under "Phase Sequence".

(2) A single alternating current is termed "single-phase" current, whereas several currents differing in phase are "poly-phase" currents. In a 3-phase system, the three currents differ in phase from each other by 120 electrical degrees, as shown in figure 24-25. A 3-phase generator may be considered as three single-phase generators combined in one machine.



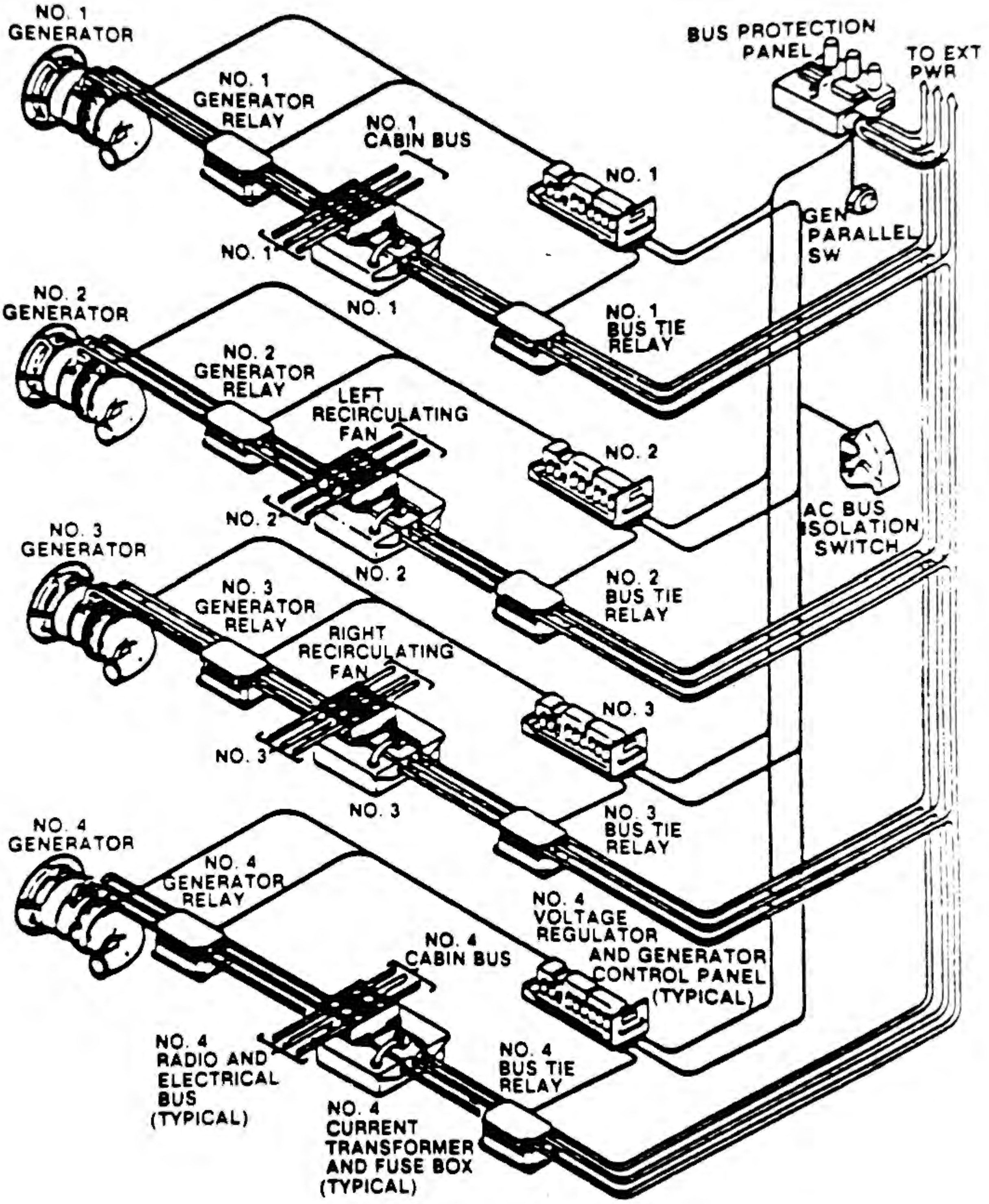
COMBINED SINE WAVES OF A 3-PHASE SYSTEM FTX80635

Figure 24-25

(3) It takes a minimum of three wires to deliver 3-phase service, but the number of wires in a service should not be confused with the number of phases. For example, a home may have 3-wire service but in all probability it is single-phase, 115/230 volts.

D. Phase Sequence

(1) In figure 24-25, phase 1 starts at zero and builds up from there. Phase 2 starts to build up 120 degrees later, followed by phase 3 which starts 240 degrees from time zero. Thus, the sequence is 1-2-3. At 360 degrees from time zero, phase 1 completes its cycle and the procedure is repeated.



AC SYSTEM POWER - FUNCTIONAL

FTX80023

Figure 24-21

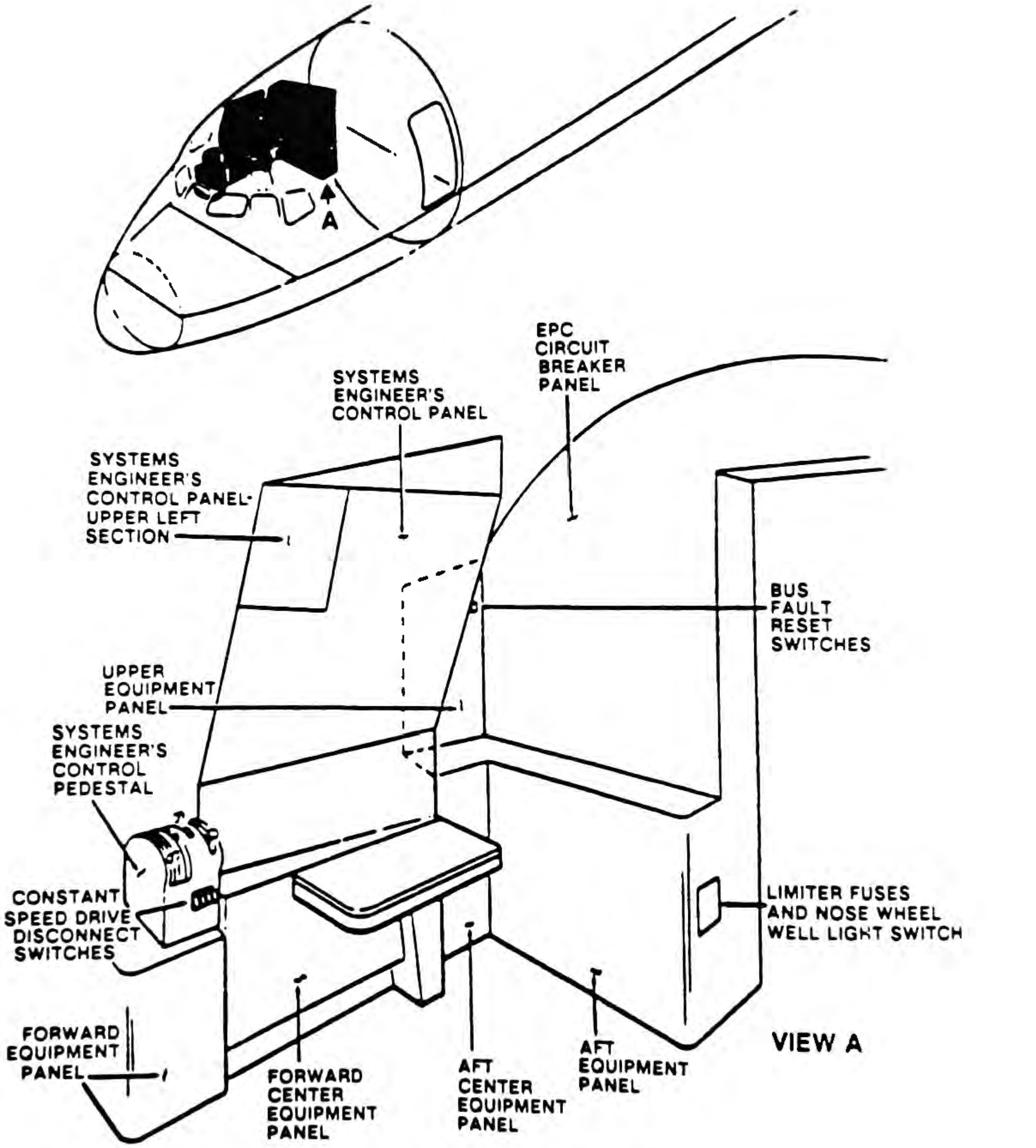
current transformer and fuse box. Seven current transformers are located inside the box; three are used for generator differential protection, two for load division circuits, one for the unbalance current circuit, and one for both the ac loadmeter and overload indicating light circuit.

(3) There are six limiter fuses, arranged in two groups of three fuses, mounted on a corresponding current transformer and fuse box for each of the four generator systems. The No. 1 and 4 systems are identical in arrangement, and the two groups of fuses connect the No. 1 and 4 generator buses to the No. 1 and 4 radio, electrical, and cabin load buses through No. 1 and 4 load monitoring relays, respectively. (See Figure 24-21) The two groups of fuses for the No. 2 and 3 systems connect the No. 2 and 3 generator buses to the left and right recirculating fan circuitry direct and to the No. 2 and 3 radio and electrical load buses through the No. 2 and 3 load monitoring relays, respectively.

(4) The power from the ac generator buses is supplied to four transformer-rectifier units; directly to No. 1 and 4 units and through the left and right ac emergency buses to No. 2 and 3 units, respectively. The transformer-rectifier units convert ac to dc to meet the dc power requirement for operating the airplane equipment.

(5) During normal paralleled operation, the ac generating system operates automatically and uses automatic protective devices to isolate system faults. The isolated fault indications are displayed on the systems engineer's control panel. Although the system operates automatically, the electrical system can be controlled and monitored by the controls and indications at the system engineer's station.

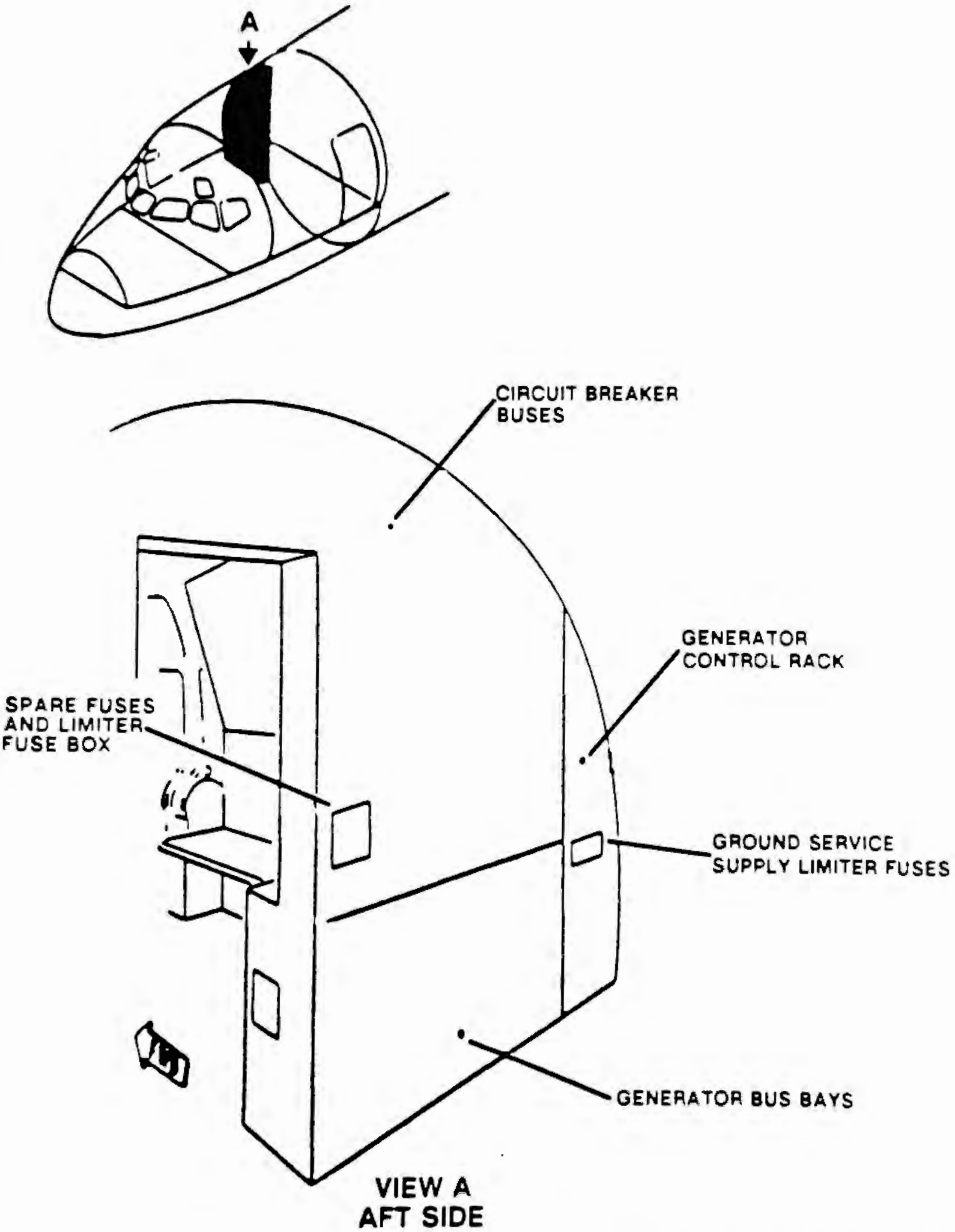
(6) The systems engineer's station is located at the electrical power center (see Figure 24-22 & 24-23). The upper left section of the engineer's control panel contains the switches, meters, and indicating lights for controlling and monitoring the ac generator systems. The bus fault reset switches are located on the upper equipment panel. Circuit breaker buses, limiter fuses, generator control rack and generator bus bay are located on the aft side of the electrical power center.


A
EPC CIRCUIT BREAKER PANEL
SYSTEMS ENGINEER'S CONTROL PANEL
SYSTEMS ENGINEER'S CONTROL PANEL-UPPER LEFT SECTION
BUS FAULT RESET SWITCHES
UPPER EQUIPMENT PANEL
SYSTEMS ENGINEER'S CONTROL PEDESTAL
CONSTANT SPEED DRIVE DISCONNECT SWITCHES
LIMITER FUSES AND NOSE WHEEL WELL LIGHT SWITCH
VIEW A
FORWARD EQUIPMENT PANEL
FORWARD CENTER EQUIPMENT PANEL
AFT CENTER EQUIPMENT PANEL
AFT EQUIPMENT PANEL

ELECTRICAL POWER CENTER AND SYSTEM ENGINEER'S STATION

FTX80025

Figure 24-22



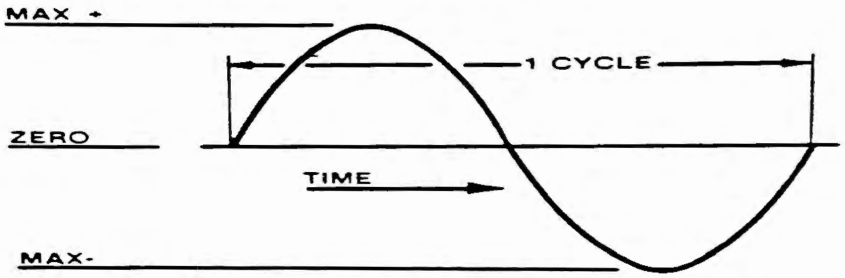
ELECTRICAL POWER CENTER AND SYSTEMS ENGINEER'S STATION

FTX80026

Figure 24-23

B. Alternating Current Frequency

(1) In an a-c circuit, the voltage and current build up from zero to a maximum of one polarity, then decay to zero, build up to a maximum value of the opposite polarity, and again decay to zero. This sequence of build up and reversal is called a "cycle", and the number of times it occurs in one second is called the "frequency". It is illustrated by a typical sine wave (see figure 24-24).



TYPICAL SINE WAVE FTX80634

Figure 24-24

(2) In a conventional generator, the frequency is dependent upon the speed of rotation and the number of poles in the generator. Two poles must pass a given point on the stator every cycle. Consequently,

$$\text{Frequency (cps)} = \frac{\text{RPM x Pairs of Poles}}{60}$$

(3) For example, with a 6-pole generator operating at 8000 rpm,

$$\text{Frequency} = \frac{8000 \times 3}{60} = 400 \text{ cps}$$

(4) For aircraft constant frequency systems, 400 cps has been adopted as a standard.

(2) The output terminals of generators are marked to show the phase sequence, and these terminals are connected to load busses which are marked accordingly. Usually they are labeled A-B-C to indicate a sequence of 1-2-3.

E. Volt-Amperes

In an a-c circuit, the product of voltage x amperage is volt-amperes (va), frequently referred to as "apparent power". In a d-c circuit, this product is "power" expressed in watts. Kilovolt-amperes (kva) is volt-amperes expressed in thousands, that is, 20,000 va = 20 kilovolt=amperes or 20 kva.

F. Winding Connections

(1) The windings of 3-phase electrical apparatus such as generators, motors and transformers can be connected in various configurations, including the "wye" illustrated in figure 24-26. The phase-to-phase voltage of the wye-connected unit is the vector sum of the voltage of two windings, which is the square root of 3 multiplied by the phase-to-neutral voltage. For example, if the phase-to-neutral voltage is 115 volts, the phase-to-phase voltage equals 115 x 3 199+ volts. This is usually indicated as 115/200 volts.

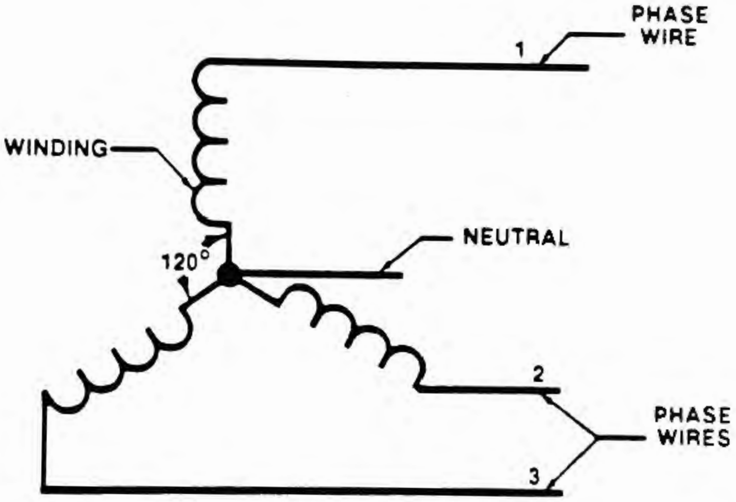
(2) Most aircraft generators are wye-connected, with the neutral attached to structure. Then they are referred to as 3-phase, 4-wire generators, the aircraft structures serving as the fourth wire.

(3) When making power feed connections to frequency-sensitive apparatus such as a 3-phase motor, the phase sequence must be a specific way in order to obtain the desired position. That is, a 3-phase motor will rotate in a certain direction when properly connected, but will rotate in the opposite direction is any two of the three power feed wires are reversed, or if the phase sequence of the power source is reversed.

(4) The neutral point of a wye-connected 3-phase motor may or may not be grounded. If one of the phase wires of an ungrounded-neutral motor is disconnected, with the two remaining wires connected, it operates as a single-phase motor. It will not start, but if already running it will continue to run provided the load is not too great. With an appreciable load, it will soon overheat, and obviously it will overheat if a single-phase start is attempted.

(5) On the other hand, if one of the phase wires of a grounded-neutral motor is disconnected, leaving the two remaining phase wires and the ground wire connected, it will operate as variation of a 2-phase motor. It will start, run and carry load, although its load-carry capabilities will be somewhat reduced from that as a 3-phase motor. For this reason, certain of the important load motors (such as fuel pumps) have grounded neutral and are so designed as to perform reasonably well when operating 2-phase.

(6) Single-phase service can be obtained form a wye-connected 3-phase system by connecteing between two of the phase wires or connecting from one phase wire to neutral (or to ground), but 3-phase service cannot be obtained directly from a single-phase system.



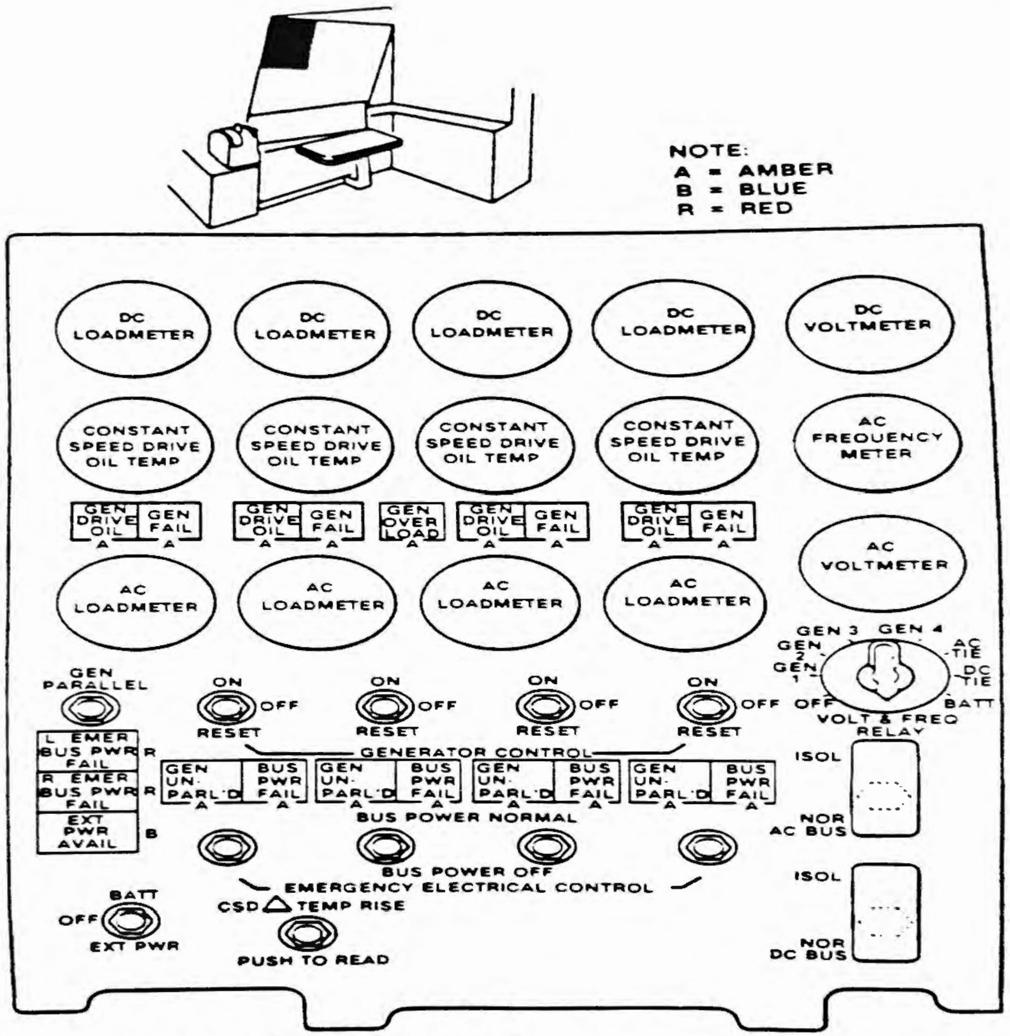
WYE-TYPE WINDING FTX80636

Figure 24-26

G. Controls and Indications (See Figure 24-27)

(1) Generator Control Switches

The four three-position generator control switches, one for each generator, can be placed in the on, off, or reset positions. When a switch is in the on position, the generator operation is automatic. In the off



NOTE:
A = AMBER
B = BLUE
R = RED

SYSTEMS ENGINEER'S CONTROL PANEL
UPPER LEFT SECTION

FTX80029

Figure 24-27

position, the generator cannot be connected to the generator bus. The momentary-contact reset position is used to close the generator field relay after the relay has been tripped by the automatic operation of the protection circuits or by the manual operation of the fire shutoff lever.

(2) Generator Parallel Switch

A momentary-contact push-button switch is used to initiate the automatic paralleling operation of the generators. Paralleling can occur only when the battery-external power switch is in the battery position, the bus isolation switch is in normal position, and the bus fault lockout circuit is deenergized. The generators cannot be paralleled when AC external power is being supplied to the AC tie bus.

(3) Voltage and Frequency Selector switch

An 8-position, rotary switch selects the indications on the AC voltmeter, frequency meter, and DC voltmeter. When the switch is in the off position, all three meters are deenergized. With the switch in any one of the four generator positions, the frequency and AC voltage of the corresponding generator is indicated on the frequency meter and AC voltmeter. In the AC tie position, the frequency and voltage of the AC tie bus is indicated on the corresponding meters. In the DC tie position, voltage applied to 28-vdc bus 1 is indicated on the DC voltmeter provided the 115/200-vac bus 1 is energized. Battery voltage is indicated on the DC voltmeter when the voltage and frequency selector switch is in the battery position.

(4) AC Bus Isolation Switch

During normal paralleled operation, the AC bus isolation switch is in the guarded normal position. Placing the switch in the isolate position opens the four bus tie relays, which deenergize the AC tie bus if the tie bus is not being supplied AC external power. As long as the switch remains in the isolate position, the generators cannot be paralleled, the preferential circuit is inoperative, and the bus tie relays cannot close automatically. One bus tie relay will close when the switch is returned to the normal position.

(5) Emergency Electrical Control Switches

(a) Four emergency electrical control switches, one for each AC load bus, are normally lever locked in the bus power normal position. Each switch has direct operational control of a corresponding load monitoring relay.

(b) When any one of the switches is placed in the bus power off position, power is removed from the corresponding AC and DC load buses. When all four switches are placed in the bus power off position, power is removed from the four AC and DC load buses. In either event, power is never removed from the transformer-rectifier units or the AC and DC emergency buses.

(6) Bus Fault Reset Switches

Four bus fault reset switches, safetied in the aft position with lockwire, are to be operated by the systems engineer to restore bus power if faults occur in flight. If the generator unparalleled lights, bus power failure lights, and the AC loadmeter indicate that a generator bus or an AC tie bus fault has caused a lockout of one or more bus tie relays, the switches are to be placed momentarily in the reset position to unlock the relays and restore normal bus power operation.

(7) AC Voltmeter

The AC voltmeter indicates the voltage of each of the four generators when the voltage and frequency selector switch is placed in a corresponding generator position, and indicates the voltage of the AC tie bus when the switch is in the AC tie position. The AC voltmeter is calibrated in volts from 0 to 150.

(8) AC Frequency Meter

The AC frequency meter indicates the frequency of each of the four generators when the voltage and frequency selector switch is placed in a corresponding generator position, and indicates the frequency of the AC tie bus when the switch is in the AC tie position. The AC frequency meter is calibrated in cycles from 380 to 420.

(9) AC Loadmeter

Four AC loadmeters indicate the portion of rated generator load that is being supplied by a corresponding generator. Each loadmeter is calibrated in rated load from 0 to 1.5. During ground operation, the AC load-meter indication should not exceed 1.0 and the indication should not exceed 1.37 during flight. When the generators are operating paralleled, the loadmeters should indicate approximately equal loads. The indications can differ if the generators are operating unparalleled. The indicators display no load indication when power to the corresponding bus is supplied from an external power supply.

(10) Generator Overload Indicating Light

An amber press-to-test light indicates when an overload exists on one or more of the generators. The indicating light comes on when an AC loadmeter indicates approximately 1.0 during ground operations or approximately 1.37 during flight. If the light comes on, all AC loadmeters should be checked to determine which generators are overloaded.

(11) Generator Unparalleled Indicating Lights

Four amber press-to-test lights indicate when any one of the four generators is not paralleled. The lights also indicate whether or not a generator is connected to the AC tie bus. In order for a generator to be connected to the AC tie bus, both the generator relay and the bus tie relay must be closed. A light comes on when either the corresponding generator relay or bus tie relay is open and goes off when both relays are closed.

(12) Generator Failure Indicating Lights

Four amber press-to-test generator failure indicating lights, one for each generator, indicate generator bearing failure. Each light is connected to a bearing failure detector terminal on a corresponding generator. In case of bearing failure, the generator failure light comes on.

(13) Bus Power Failure Indicating Lights

Four amber press-to-test bus power failure indicating lights indicate power failure of the respective AC load buses, When a load monitoring relay opens, power to the corresponding load bus is interrupted and the associated light comes on.

(14) Emergency Bus Power Failure Warning Lights

Two red press-to-test warning lights for the left and right AC emergency buses come on to indicate power failure of the respective buses. When the emergency bus power failure warning lights are on, a master warning light, located on the glareshield, should be on.

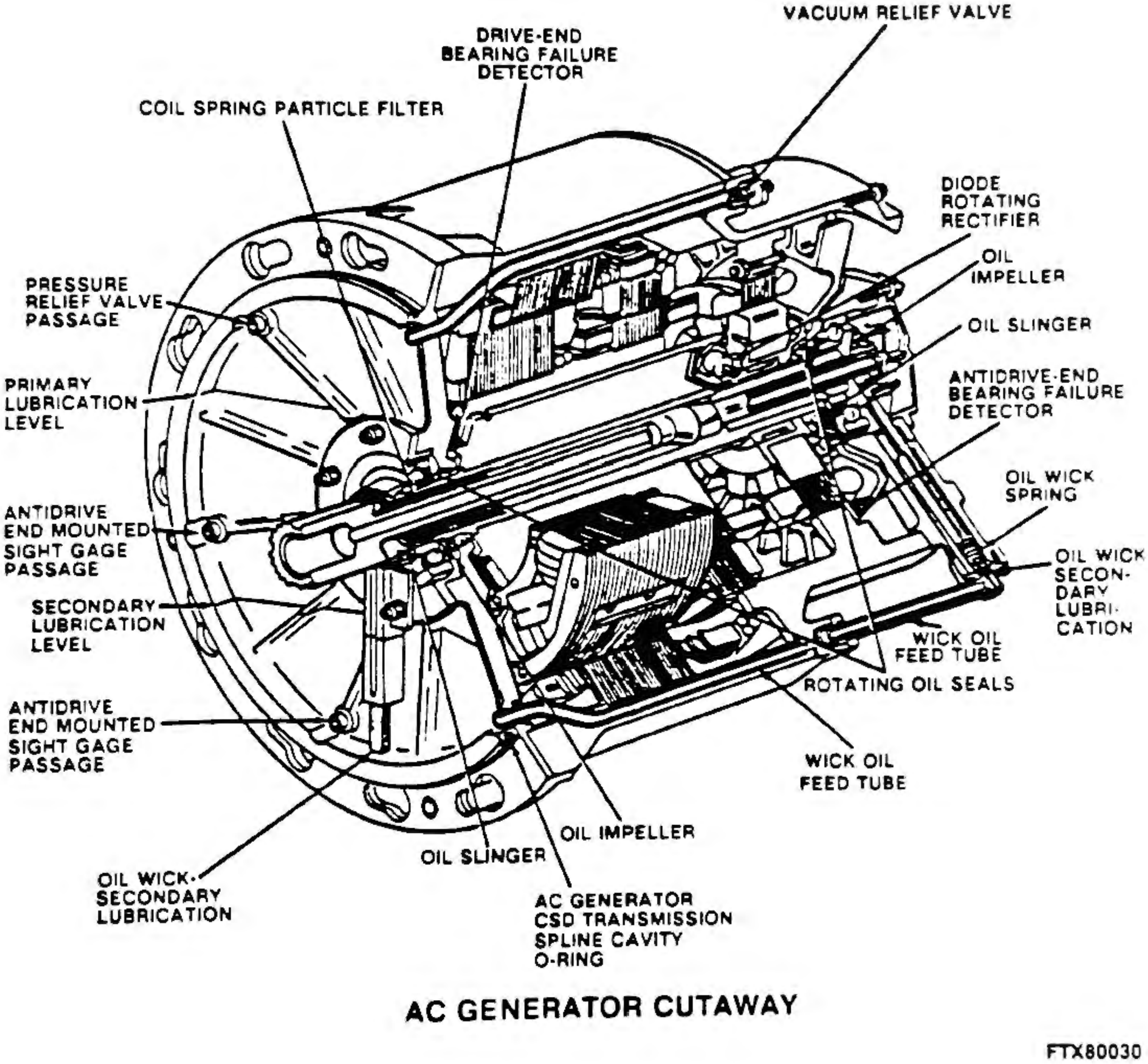
H. Component Description

(1) AC Generator (See Figures 24-28 and 24-29)

(a) The four 30-kva, 3-phase, 400-cps, 115/200 -volt, brushless generators are mounted on and driven by four constant speed drive CSD transmissions. Each generator is driven at a constant speed, within narrow limits, regardless of engine operating speeds and applied electrical loads.

(b) The generator bearings and the drive shaft spline are lubricated, either by a primary or a secondary method, with the oil contained in the CSD transmission output spline cavity. Normally, the oil level in the cavity is above the spline and the primary method of lubrication is in effect. The drive-end bearing is lubricated directly from the spline cavity. A rotating oil impeller, adjacent to the bearing, draws the oil through the bearing, around the outside diameter, and back to the spline cavity through axial grooves in the bearing liner. Oil from the spline cavity is also supplied to a small cavity at the antidrive-end, through the generator rotor shaft and through porting holes in the rotor support shaft. The antidrive-end bearing is lubricated in a manner similar to that described for the drive-end bearing.

(c) A secondary, backup method is provided to ensure lubrication for the bearings if the spline cavity oil level is below normal. An integral oil line on the bottom of the generator transfers oil to the antidrive-end from the drive-end sump. The ends of the oil wicks,


VACUUM RELIEF VALVE
DRIVE-END BEARING FAILURE DETECTOR
COIL SPRING PARTICLE FILTER
DIODE ROTATING RECTIFIER
OIL IMPELLER
OIL SLINGER
PRESSURE RELIEF VALVE PASSAGE
PRIMARY LUBRICATION LEVEL
ANTIDRIVE-END BEARING FAILURE DETECTOR
OIL WICK SPRING
ANTIDRIVE END MOUNTED SIGHT GAGE PASSAGE
OIL WICK SECON-DARY LUBRI-CATION
SECONDARY LUBRICATION LEVEL
WICK OIL FEED TUBE
ROTATING OIL SEALS
ANTIDRIVE END MOUNTED SIGHT GAGE PASSAGE
WICK OIL FEED TUBE
OIL IMPELLER
OIL SLINGER
OIL WICK-SECONDARY LUBRICATION
AC GENERATOR CSD TRANSMISSION SPLINE CAVITY O-RING

AC GENERATOR CUTAWAY

FTX80030

Figure 24-28

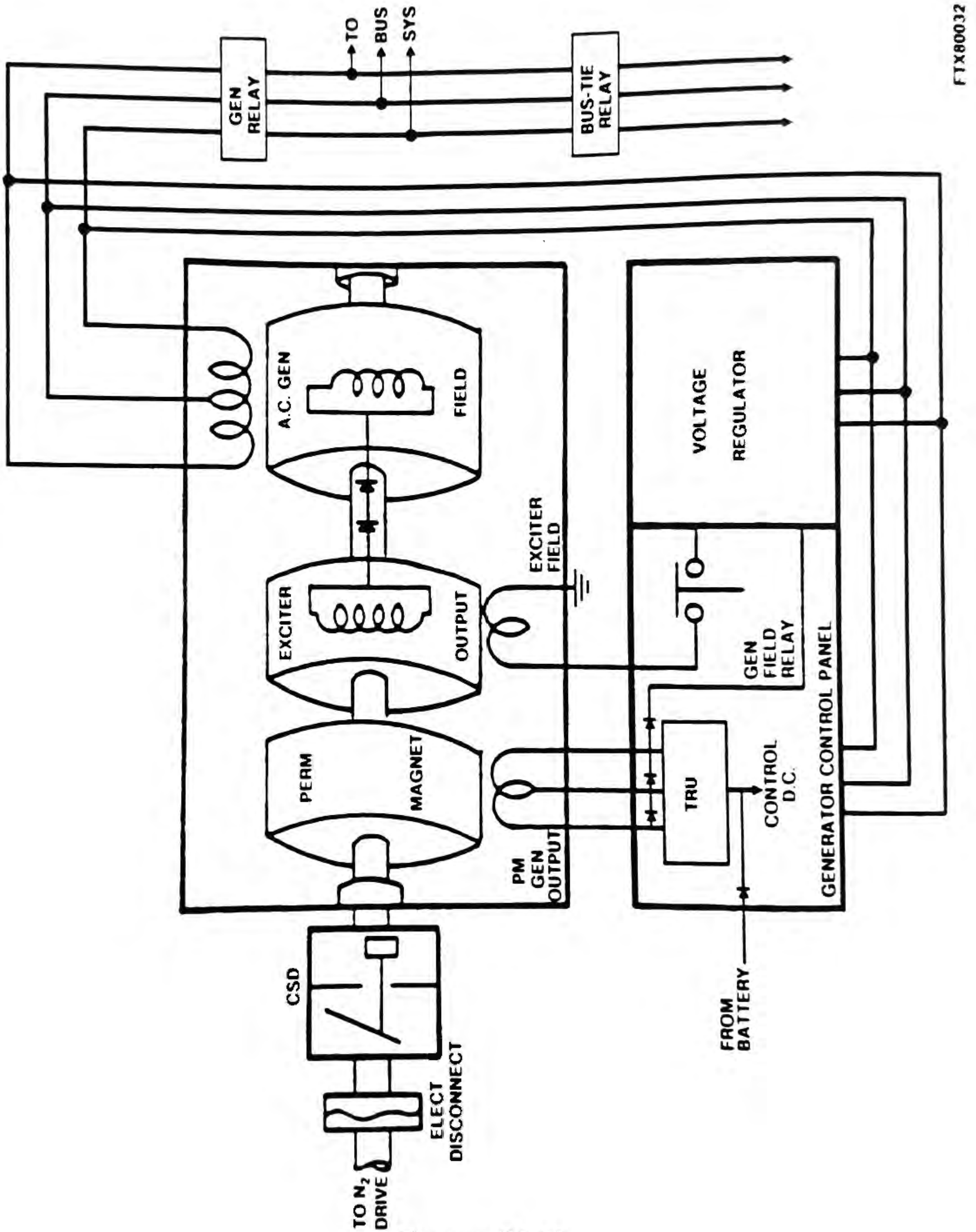

FTX80032
GEN RELAY
TO
BUS
SYS
BUS-TIE RELAY
A.C. GEN
FIELD
EXCITER
OUTPUT
EXCITER FIELD
PERM
MAGNET
PM GEN OUTPUT
VOLTAGE REGULATOR
GEN FIELD RELAY
TRU
CONTROL D.C.
GENERATOR CONTROL PANEL
FROM BATTERY
CSD
ELECT DISCONNECT
TO N_2 DRIVE

Figure 24-29

provided for both bearings, are in the oil. The oil is drawn through the wicks by capillary action and the draft created by the rotating impellers draws the oil through the bearings.

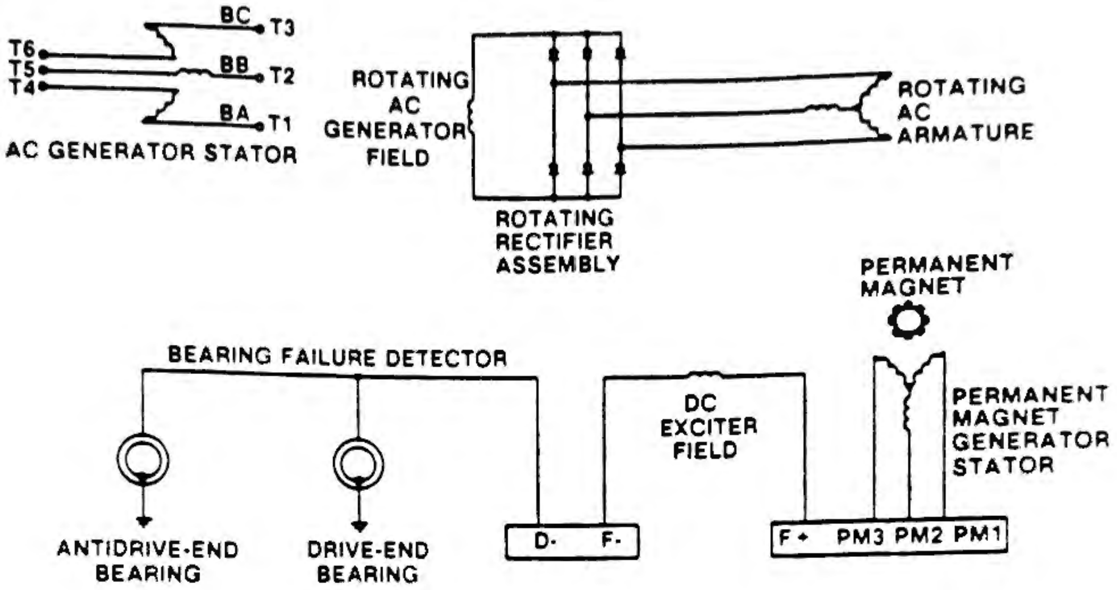
(d) A system of lines and porting, from the spline cavity through the generator housing, provides for a pressure relief valve which is vented overboard, a vacuum relief valve, and three oil level sight gages. The valves and sight gages are located on the exciter housing.

(e) A fan, within the generator case, is located on the antidrive-end shaft of the generator to ensure cooling air for the generator during operation. Cooling air is taken from the fan bleed air section of the engine by a duct connected to the blast cap mounted on the antidrive-end of the generator. The cooling air is passed through the generator, collected in a shroud assembly mounted on the drive-end of the generator, and ducted overboard.

(f) The AC brushless-type generator does not require electrical connections or brushes between the rotating and nonrotating portion of the generator. The brushless generator consists of three AC generators, the permanent magnet generator (PMG), the exciter, and the main AC generator, enclosed in a single housing. The rotor of the PMG, exciter armature, rotating rectifiers, and AC generator field are mounted on the generator shaft. The PMG stator armature, exciter field windings, and AC generator stator armature are secured to, and insulated from, the generator frame.

(g) The 3-phase windings of the AC generator stator are wye-connected with each end of each phase winding connected to a terminal of the 6-post terminal strip, which is mounted externally on the generator. (See Figure 24-30) Terminals T1, T2, and T3 are the power terminals, and T4, T5, and T6 are the neutral terminals of phase A, phase B, and phase C, respectively. A 4-post and a 2- post terminal strip are also provided. PM1, PM2, and PM3 are the permanent magnet generator (PMG) phase windings, F- and F+ are the exciter field windings, and D- is the bearing failure detector.

(h) The permanent magnet generator (PMG) is a 3-phase, 600-cps, flux switch inductor generator which utilizes permanent magnets for excitation. The output is unregulated and varies as the load



AC GENERATOR INTERNAL WIRING SCHEMATIC

Figure 24-30

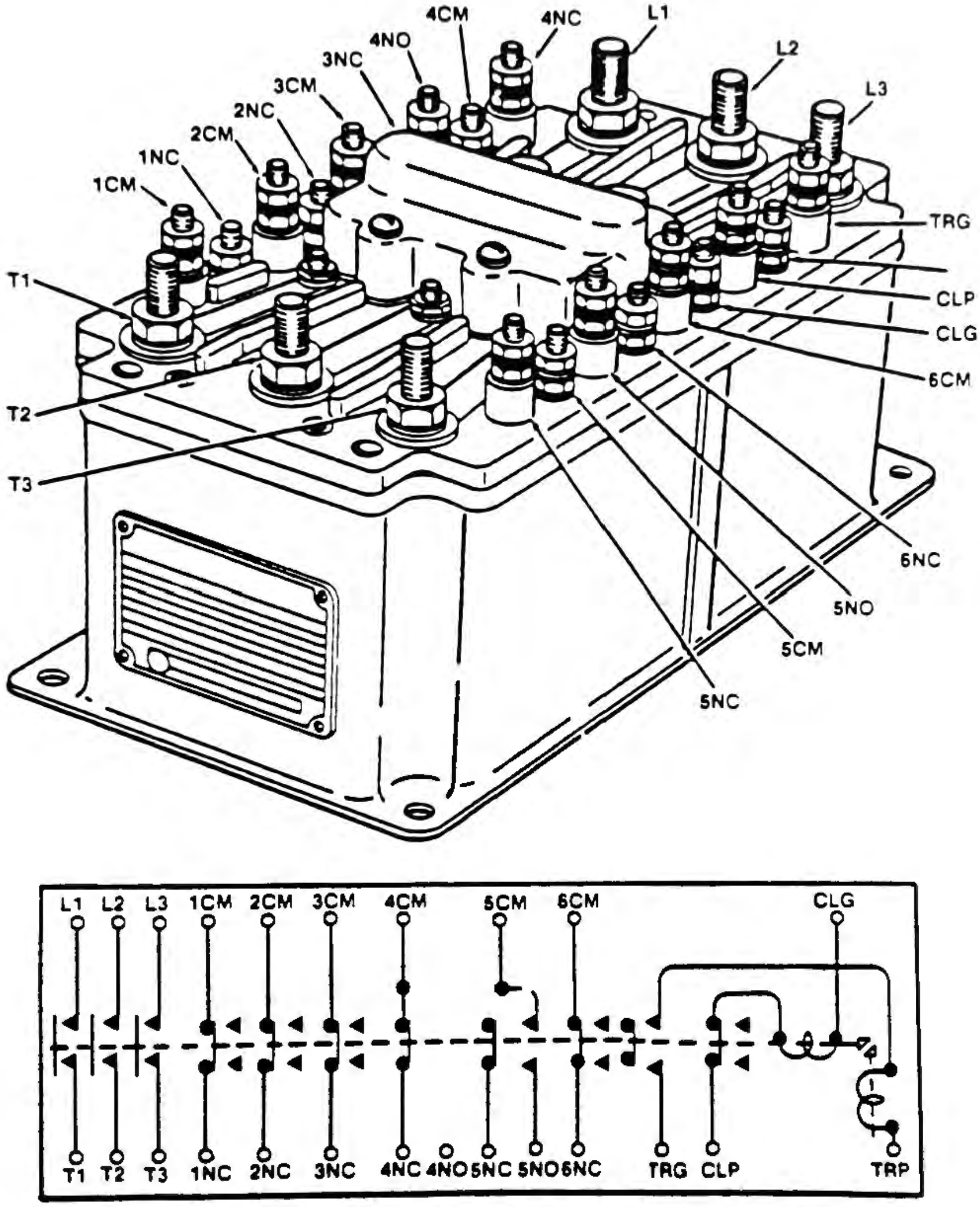
FTX80031

varies. The PMG produces initial excitation and supplies power to the voltage regulator portion of the voltage regulator and generator control panel.

(i) The exciter, which provides power for the rotating AC generator field, uses a stationary DC exciter field and a rotating AC armature. Six silicone-power diodes, connected in a 3-phase full-wave bridge, are mounted inside the generator rotor. Regulated DC power form the AC voltage regulator is fed to the stationary DC exciter field. An AC voltage is produced in the rotating armature, rectified by the rotating rectifiers, and fed to the rotating generator field. The rotating field induces 3-phase power in the generator output winding.

(2) AC System Power Relays (See Figure 24-31)

(a) The four generator relays and four bus tie relays are identical units and are located in the generator bus bay on the aft side of the electrical power center. Each of the four AC generators can be connected to, or removed from, its AC load bus or the AC tie bus by the corresponding generator relay or bus tie relay, respectively.



AC SYSTEM POWER RELAY

FTX80033

Figure 24-31

(a) The eight 175-ampere, 3-pole, 200-volts AC latching relays are operated electrically and latch mechanically. In addition to close and trip coils, which are energized by DC power, each relay has three sets of main power contacts, one for each power phase, and eight sets of auxiliary contacts. Six sets of auxiliary contacts are used in the ac system protective, control, and indicating circuits. The other two sets of auxiliary contacts are used to control the operation of the relay close and trip coils and to prevent the coils from being energized continuously.

(b) The close coil, for closing the relay contacts, is energized when the close coil circuit is completed. The contacts remain closed when the close coil is deenergized because a mechanical latching mechanism locks the relay contacts in the closed position. To unlatch or trip the relay, the trip coil must be energized. Energizing the trip coil releases the latching mechanism and the spring-loaded contacts of the relay open. When the trip coil is deenergized. the relay contacts are held open by spring tension.

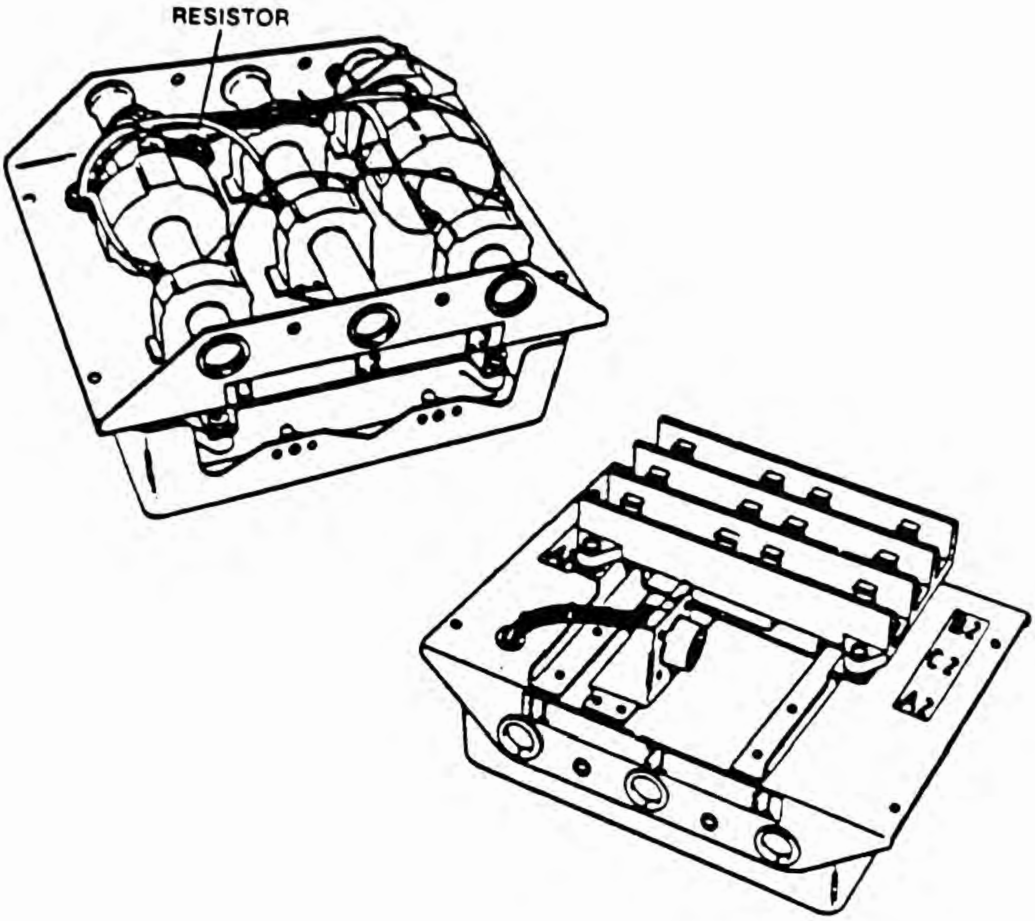
(3) AC Load Monitoring Relays

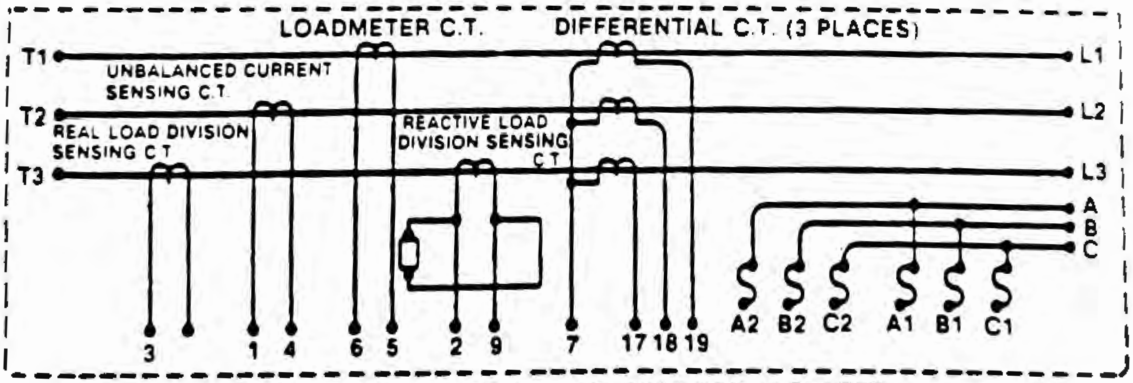
(a) The four AC load monitoring relays are located in the aft equipment panel. The relays connect the generator buses to the AC load buses. Each relay provides a means of removing power from the respective AC load bus when a corresponding emergency electrical control switch is placed in the bus power off position.

(b) Each relay is a 4-pole, nonlatching relay. Three sets of normally open contacts control the 3-phase load and are identified as A1-A2, B1-B2, and C1-C2. Normally closed contacts D1-D2 are used in the bus power failure warning light circuitry.

(4) Current Transformer and Fuse Boxes (See Figure 24-32)

Four current transformer and fuse boxes, one for each generator, are located in the generator bus bay between the generator relays and the bus tie relays. A set of feeder leads s connected between each generator relay and bus tie relay. The leads also supply power from the bus tie relay to the fuse terminals mounted on the face of the current transformer and fuse box. A receptacle connection provides 3-phase AC power to the seven current transformers located inside the box. The current transformer used with the AC loadmeter and generator




LOADMETER C.T.
DIFFERENTIAL C.T. (3 PLACES)
T1
T2
T3
L1
L2
L3
UNBALANCED CURRENT SENSING C.T.
REAL LOAD DIVISION SENSING C.T
REACTIVE LOAD DIVISION SENSING C.T
A
B
C
3
1
4
6
5
2
9
7
17
18
19
A2
B2
C2
A1
B1
C1

CURRENT TRANSFORMER AND FUSE BOX (4 PLACES)

CURRENT TRANSFORMER AND FUSE BOX

FTX80034

Figure 24-32

overload circuits is on phase A. The current transformer used with the unbalanced current circuit is on phase B. The two current transformers used with the real load and reactive load division circuits are on phase C. Three current transformers for the generator differential protection circuit are on phases A, B, and C. A resistor is connected in parallel with the reactive load current transformer on phase C.

(5) Generator Differential Current Transformer Junction Boxes

(a) Each of the four generator differential current transformer junction boxes is located on the right side of the aft face of the forward firewall of each nacelle.

(b) Three current transformers are installed inside each junction box in such a manner as to permit each of the three phase leads of the generator neutral to pass through the center of its current transformer. The three leads are then connected to ground inside the box. To ensure a ground connection to the airplane, an additional lead grounds the box to the mounting bolt of the left forward engine mount.

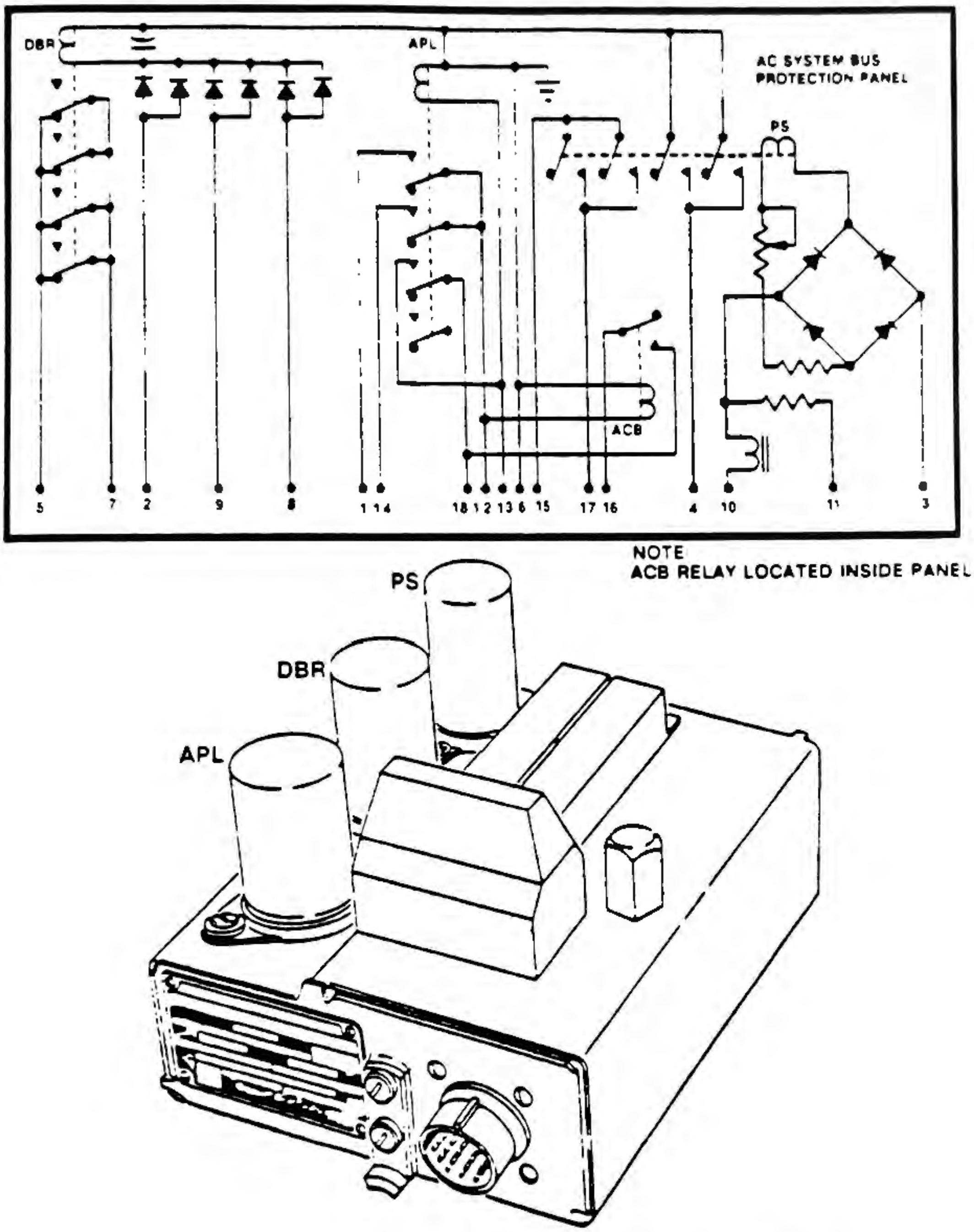
(c) These current transformers are used in the differential protection circuit. Access to the junction box is through the engine right forward access door.

(6) Bus Protection Panel (See Figure 24-33)

(a) The bus protection panel is located in the generator control rack on the aft side of the electrical power center.

(b) The four basic circuits in the bus control panel are the phase sequence, autoparallel lockout, AC bus, and dead bus relay circuits.

1 The phase sequence circuit senses phase sequence of the external electrical power supply and prevents connecting external electrical power of improper phase rotation to the airplane load distribution buses.



NOTE
ACB RELAY LOCATED INSIDE PANEL

AC SYSTEM BUS PROTECTION PANEL

FTX80035

Figure 24-33

2 The autoparallel lockout relay prevents paralleling of the generators until the operator desires parallel operation. Closing the relay applies a signal to the autoparallel sensing circuits to automatically parallel the generators.

3 The AC bus relay provides an interlock to the autoparallel lockout circuit. This, in turn, prevents random paralleling of the generators if the autoparalleling control and tie bus voltage circuit breaker is open or if there is a loss of voltage on phase A of the AC tie bus.

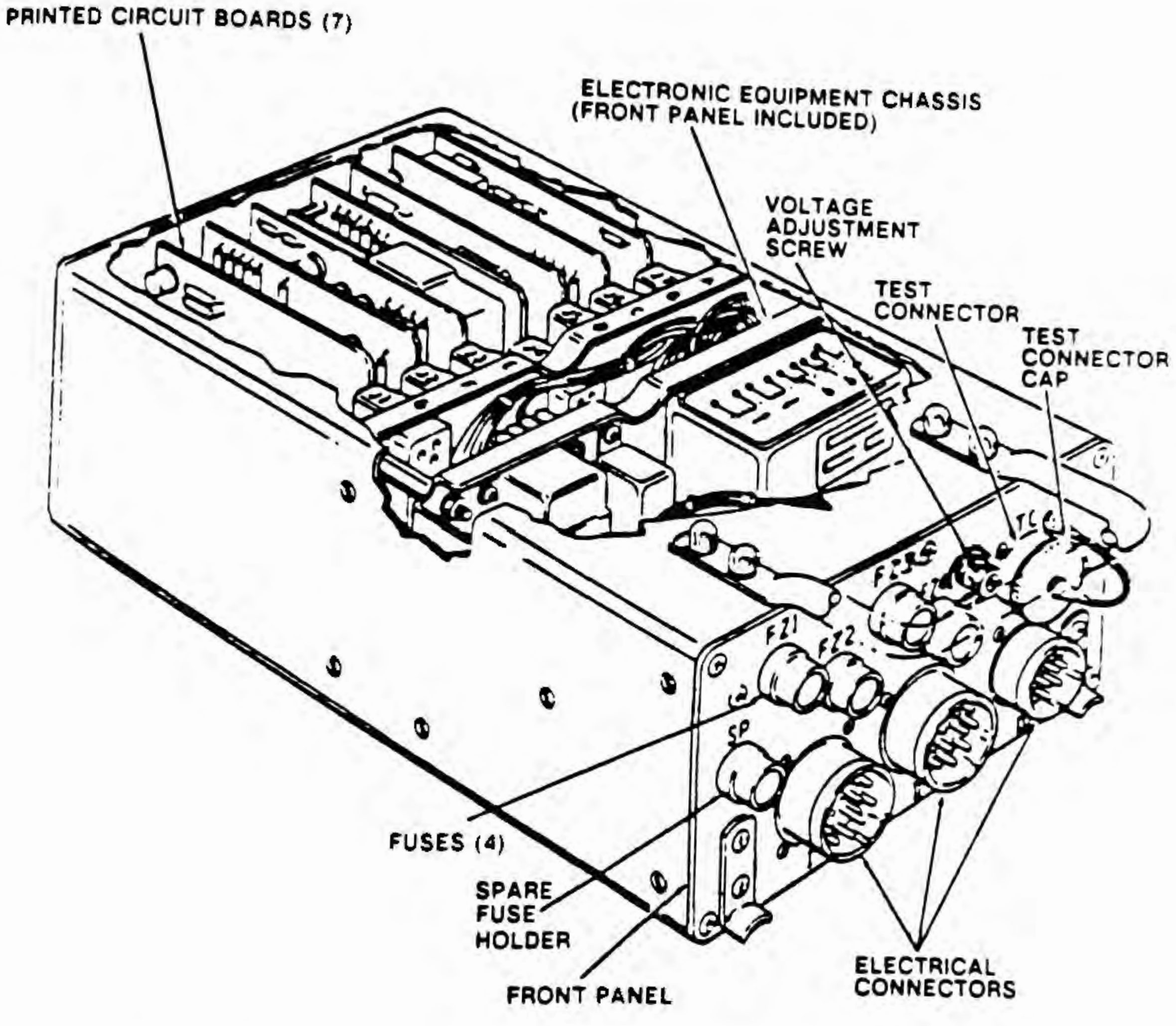
4 The dead bus relay is used to sense or detect a no-voltage condition on the AC tie bus.

(7) Generator Overload Detectors

(a) The generator overload detectors, one for each generator, are located in the EPC forward center equipment panel. A current transformer, in the current transformer and limiter fuse box sensing current on phase A, is series connected through the corresponding AC loadmeter to provide input signal to the detector. Outputs of the four detectors are parallel connected to the generator overload indicating light. Any generator operating under overload condition will cause the light to come on. The change from ground to flight condition is controlled by the operation of a ground control relay. The relay is controlled by a nose gear oleo switch, which is operated by the ground shift mechanism.

(8) Voltage Regulator and Generator Control Panel (See Figure 24-34)

(a) The voltage regulator and generator control (VR/GC) panels, one for each of the four AC generator systems, are located in the generator control rack on the aft side of the electrical power center. Each VR/GC panel consists of a front panel and an electronic equipment chassis. Solid-state components and printed circuitry with modular assemblies are used to provide a compact unit. As a result, the VR/CG panel combines the separate functions of generator voltage regulation, system control, and system protection. (For abbreviations used in this section, see Figure 24-35)



VOLTAGE REGULATOR AND GENERATOR CONTROL PANEL

FTX80036

Figure 24-34

ABBREV.	CIRCUIT OR PART NAME
ACB	AC BUS
AP	AUTOPARALLEL
APL	AUTOPARALLEL LOCKOUT
BFLO	BUS FAULT LOCKOUT
BFR	BUS FAULT RESET
BFTD	BUS FAULT TIME DELAY
BI	BUS ISOLATION
BIR	BUS ISOLATION RELAY
BPP	BUS PROTECTION PANEL
BR	BATTERY RELAY
BTC	BUS TIE CONTROL
BTR	BUS TIE RELAY
CSD	CONSTANT SPEED DRIVE
CT & FB	CURRENT TRANSFORMER AND FUSE BOX
DBR	DEAD BUS RELAY
DP	DIFFERENTIAL PROTECTION
DCT	DIFFERENTIAL CURRENT TRANSFORMER
EEC	EMERGENCY ELECTRICAL CONTROL
EPC	ELECTRICAL POWER CENTER
EPR	EXTERNAL POWER RELAY
F & LC	FREQUENCY AND LOAD CONTROL
FR	FIELD RELAY
FRC	FIELD RELAY CONTROL
FTD	FIELD TRIP TIME DELAY
FZ	FUSE
GC	GENERATOR CONTROL
GCT	GENERATOR DIFFERENTIAL CURRENT TRANSFORMER
GR	GENERATOR RELAY
GRC	GENERATOR RELAY CONTROL
	GENERATOR RELAY CONTROL RELAY AUXILIARY
LCT	LOAD DIFFERENTIAL CURRENT TRANSFORMER
LMR	LOAD MONITOR RELAY
OUVRS	OVERVOLTAGE, UNDERVOLTAGE, AND VOLTAGE REGULATOR SENSING
OV	OVERVOLTAGE
PMG	PERMANENT MAGNET GENERATOR
RCT	REACTIVE LOAD DIVISION SENSING CURRENT TRANSFORMER
RLD	REACTIVE LOAD DIVISION
RS	REGULATED SUPPLY
T	TRANSFORMER
TDR	TIME DELAY RESET
TO	AUTOPARALLEL PREVENTION
TR	TRANSFORMER-RECTIFIER
UC	UNBALANCE CURRENT
UCT	UNBALANCE CURRENT SENSING CURRENT TRANSFORMER
UCTD	UNBALANCE CURRENT TIME DELAY
UF	UNDERFREQUENCY
US	UNDERSPEED
USS	MAGNETIC UNDERSPEED SENSOR
USTD	UNDERSPEED TIME DELAY
UV	UNDERVOLTAGE
VR	VOLTAGE REGULATOR
VR/CC	VOLTAGE REGULATOR AND GENERATOR CONTROL
ZNS	ZERO NEGATIVE SEQUENCE

ELECTRICAL POWER ABBREVIATIONS

FTX8059A

Figure 24-35

(a) Located on the front panel of the VR/GC panel are four fuses with indicating lights, a spare fuse holder containing two spare fuses, four connector receptacles, and a voltage adjustment screw. Three of the four fuses, FZ1 through FZ3, are arranged in circuit form to isolate bus tie relay close circuit, generator relay close circuit, and indicating light circuit faults from the control power supply. Fuse FZ4 provides separation between the permanent magnet generator (PMG) transformer-rectifier and battery backup control power supplies and between the generator relay and bus tie relay trip buses if the trip bus for either the bus tie relay or generator relay is faulted. Three connector receptacles are used to connect the airplane wiring to the VR/GC panel. The fourth connector provides test connections which are used during specific VR/GC test procedures. The voltage regulator is adjusted to the normal operating voltage of the electrical system by using the voltage adjustment screw.

(b) The electronic equipment chassis assembly contains solid state circuits, control relays, transformer assemblies, transformer-rectifier units, and circuit boards. Seven printed circuit boards are connected to a circuit board connector panel. Each board, identified with a letter, contains the printed circuits for the specific functions which are listed as follows:

1 A - Overvoltage, undervoltage, differential protection, and time delay reset.

2 B - Field relay control, generator relay control, underspeed, and underspeed time delay.

3 C - Zero-negative sequence and bus fault time delay.

4 D - Voltage sensing, transformer-rectifier, regulated supply, reactive load division, and autoparallel.

5 E - Voltage regulator and underfrequency bias network.

6 F - Bus tie control, unbalanced current, and unbalanced current time delay.

7 G - Negative sequence transformer, autoparallel transformer, and autoparallel prevention.

(c) The generator output voltage is regulated to the 115/200-vac level by a solid state voltage regulator (VR) in the VR/GC panel. The regulation circuit controls excitation of the generator exciter filed by using a source of power from the permanent magnet generator (PMG) contained within the ac generator. This PMG potential is rectified within the VR/GC panel to furnish power to the output stage of the VR. The exciter field current supplied by the VR is limited to a safe value by the current limit action of the VR summing amplifier. This action prevents destruction of the VR power transistor or exciter during specific operating or fault conditions. Since the VR current limit action is ineffective during an underspeed condition, an underfrequency bias network is included in the VR circuitry to limit generator output voltage when the frequency is below 350 cps.

(d) The primary 28-vdc control power that operates the power relays and internal VR/GC circuits is supplied by the transformer-rectifier (TR) in the VR/GC panel and /or the airplane battery bus. A small portion of this 28-vdc control power is used to supply regulated 16-vdc power to most of the protection circuits and to all stages of the voltage regulator except the stability network and power amplifier stages. Generator relay control (GRC), bus tie control (BTC), and generator relay auxiliary (GRX) relay circuits control the operation of the generator relay (GR), bus tie relay (BTR), and indicating lights. The field relay (FR) controls the generator exciter field circuit. The dc control power distribution system is designed so that in the event of a fault condition, proper protective operation is maintained.

(e) The excitation of the generator exciter field is provided as a train of square-wave pulses where the width of the pulse is the control mechanism. The source of excitation is the permanent magnet generator (PMG) during all modes of operation. The PMG is a floating power supply which is isolated from ground. One side of the field is grounded and the other side is connected through the field relay to the negative side of the rectified PMG output. The switching of a power transistor in the voltage regulator allows current to flow through the field during the on portion of the duty cycle. The current is averaged to the required excitation level by two diodes across the field.

(f) The voltage regulator portion of the VR/GC panel consists of six stages. The output from the overvoltage, undervoltage, and voltage regulator sensing (OUVRS) circuit is fed into a stability network. The function of the network is to attenuate the effect of load transients on the VR. A certain portion of the sensed signal selected by the voltage adjustment potentiometer R7 is compared against a fixed reference voltage from VR1 in the pre-amplifier and reference stage. The base current which drives transistor Q32 is increased or decreased by the voltage differential of R7 sensing and VR1 reference signals. The output of sensing is 180-degrees out-of-phase with the output of the pre-amplifier. The pre-amplifier and reference constitute the first stage of the VR.

(g) In the sawtooth oscillator stage, a simple relaxation oscillator composed of Q1 and RC charging network determines the switching rate of the regulator. The rate can be adjusted by variable resistor R6 to a level preferably below the ripple frequency of the sensing voltage. Rate adjustment eliminates the modulation caused by the interaction of the two frequencies. The generated sawtooth is transferred to the input of the summing amplifier through the emitter follower Q2. The dc component is eliminated by C2 and the sawtooth is attenuated to a suitable level by R16.

(h) At the input of the summing amplifier stage, the sawtooth is super-imposed on the dc level of the pre-amplifier output which appears on the junction of voltage divider R14 and R15. The signal drives Q31 base and Q31 collector voltage is 180-degrees out-of-phase with the input signal. Current limit or under-frequency bias network action is accomplished by the summing amplifier stage. During normal operating or faulted conditions, the current limit action is effective. Capacitor Q6 is charging up to the maximum voltage level appearing across R28 during the on period of the output stage. During the off period of the duty cycle, C6 is discharging through R29 and R32, lifting the voltage level of the emitter of Q31 and limiting the on time of the summing amplifier which, in turn, determines the duty cycle of the regulator. During engine startup, engine shutdown, or any other condition when the generator output frequency is low, the underfrequency (UF) bias network in the UF circuit inserts a bias signal at the Q3 emitter and, as a result, the transistor is prevented from going into saturation and causing high currents.

(i) The switching capability of the Schmitt trigger stage is dependent on the output of the summing amplifier which is connected to the input of Q4. When the voltage level of Q31 is high enough to break down the base emitter junction of Q42, Q4 changes from a stable to a quasistable state, Q42 turns on, and Q41 turns off. Q4 remains in a quasistable state until the collector voltage of Q31 sinks below the base voltage of Q42. The Schmitt, Q4, then switches back to a stable state, Q41 turns on, and Q42 turns off. The on time of Q41 corresponds to the on time of the voltage regulator.

(j) The output stage power amplifiers, Q6 and Q7, are driven by transistor Q5. When Q41 of the Schmitt is on, transistor Q5 is triggered into a conducting state. The output pulse delivered to the collector of Q5 is the driving signal for the power amplifier. The power source for this stage is the PMG rectified output which is connected to the collectors of Q6 and Q7. During the on time of the power stage, the entire PMG voltage is applied across the field of the generator and across R28 in the voltage regulator. During the off time, the total voltage is supported by the power stage transistors. The field current circulates through two diodes, CR223 and CR213, during the off time of the voltage regulator. Therefore, an average field current flows through the field coil. The value of the field current depends on the duty cycle of the VR. To increase the stability of the VR, a negative feedback is applied at the pre-amplifier input. The voltage appearing at Q5 collector is fed back to Q32 input through the RC network of R30 and C5.

(k) The underfrequency (UF) bias network limits the field current during an underspeed condition. A sensing signal at transformer T9 is connected to the secondary of sensing transformer T1 in phase C of the OUVRS circuit. The signal is attenuated, rectified, and filtered through a two-stage RC integrator in the UF circuit. The UF circuit is designated to attenuate all signals above 350 cps. Below this frequency, the attenuated signal level is gradually decreased to a fixed level of 180 cps which corresponds to the maximum output of the circuit. The first half of Q38 is turned on and CR49 is back-biased when the frequency is above 350 cps. As soon as the frequency is decreased to 350 cps, the second half of Q38 is gradually turned on and the first half starts to turn off. As the frequency decreases further below 350 cps, the second half of

Q38 turns on more completely. When Q38, C1 collector voltage is high enough to break down the back-biased CR49, a bias signal is established in the summing amplifier stage of the VR. The voltage level is raised at this point, the regulator is starting to turn off, and the output voltage and field current is decreasing. While the frequency is below 350 cps, the underfrequency bias network limits the field current below 2.1 amperes.

(l) The VR/GC transformer-rectifier (TR) supplies 28-vdc control power. Stepdown transformer T3 receives three-phase, 95-vac, line-to-line power from the PMG. The dc output from the full-wave rectifier is filtered by C26 and R204. A transient suppression network consisting of zener diodes VR5 and VR6 protect the VR/GC panel from high-transient voltages. If a fault occurs in the dc control power distribution system, the protection circuits of the VR/GC panel and the fuses will provide fault isolation. A small portion of the 28-vdc control power is used to provide a regulated supply of 16-vdc power. Q28 regulator, shunted by resistor R104, is capable of regulating any voltage between 20 and 32 vdc. If voltage is below 20 or above 32 vdc, the regulator is operating but the regulating capability is decreased. The output voltage of 15 to 16 vdc depends on the tolerance reference of zener diodes Vr30, VR31, and VR32.

(m) The generator relay control (GRC) circuit controls the opening and closing of the generator relay (GR) during engine startup, normal or faulted operating conditions, and engine shutdown.

1 Normally, before an engine is starting, a source of external electrical power is connected to the airplane electrical system and the GC switch is placed in the on position. At this time, the corresponding field relay and bus tie relay are closed and the generator relay is open. Since undervoltage conditions exist, GRC lockout switch S22 is kept in the off state. Although the GC switch is in the on position and 28-vdc power is applied to the GRC relay coil, the relay cannot be energized because the back-bias of VR21 prevents current flow through transistor Q24. The cathode voltage of VR21 is clamped by Q23 and TDR Q9 through CR129 and CR130. With the GRC relay deenergized, the ZNS time delay is locked out by GRC-1 and the GR close coil cannot be energized because GRC-2 is open. When the engine is started and generator output voltage

and frequency have reached the specific limits, GRC lockout switch Q22 is turned on, Q9 and Q23 are turned off, and VR21 is forward-biased. Q24 is turned on by the forward-biased VR21 and the GRC relay is picked up. Through GRC-1 contact, an interlock is established between the GC switch and the GRC lockout Q22 to keep the GRC relay from dropping out while GRC Q22 is deenergizing. The GRC-1 contact also locks out the ZNS time delay circuit, preventing the tripping of the BTR before the GRC relay is picked up. The GR close coil is energized through GRC-2 contacts as soon as the BTR opens and the GRX relay is picked up with the closing of GR-5. If no UV, US, or ZNS fault occurs, the GR can now be opened or closed by placing the GC switch in the off or on position. Up until this time, the GR has been controlled by the automatic operation of the GRC circuit.

2 The electrical system is protected against overvoltage, undervoltage, differential current, or underspeed conditions. During faulted conditions, the OV, UV, or DP circuit will remove the generator from the generator bus and remove the excitation from the generator exciter field. The US circuit can remove the generator from the generator bus or prevent the generator from being connected to the generator bus but cannot remove the excitation from the generator exciter field.

3 With system operation normal and the GC switch placed in the on position, an OV, UV, or DP fault will trip the FR. The input at VR21 is grounded through CR130 by FR-1 contact, turning Q24 off. The GRC relay drops out and the trip coil of the GR is energized through GRC-1 contact which is connected to ground. The GR power relay opens and the GRX relay drops out with the opening of GR-5. Q22 of the GRC lockout is held in the off state only by the UV circuit. Q9 of the TDR is on, clamping the OV and UV time delays and the GC switch. FR-1 is opened by placing the GC switch in the reset position momentarily. If the generator output voltage builds up to a nominal level, Q22 of the GRC lockout turns on, switching Q9 and Q23 off. The GRC relay is enabled and can now be energized. If the generator output level is not above the UV pickup level after the GC switch is placed in the momentary reset position, the GRC lockout circuit will prevent the en-

ergizing of the GRC relay by clamping the input of VR21 through CR129 and Q23. The GRC lockout prevents the UV from timing out through the TDR circuit.

4 The operating of the GRC circuit is the same during underspeed fault conditions except that the FR cannot be tripped by the underspeed fault. When an underspeed condition exists for more than one second, the GRC relay is deenergized by the clamp on the input of VR21 through CR131 and USTD SCR3. After the GRC relay drops out, the GR trips, and the GRX relay drops out. The opening of GRX-2 removes the ground from the USTD circuit and SCR3 turns off. The GRC lockout circuit will prevent the closing of the GRC relay as long as the US fault condition exists.

5 Engine shutdown operation is similar to US fault protection. The GC switch can be left in the on position and, as the engine is shut down, the GRC relay is deenergized by the USTD circuit. The GR opens and the generator is removed from the bus. Timing out of the UV circuit through the TDR is prevented by the GRC lockout circuit. No field trip occurs. The generator is protected from excessive excitation by the VR/GC underfrequency bias network.

(n) The bus tie control (BTC) circuit controls the opening and closing of the bus tie relay (BTR) during engine startup, normal or faulted operating conditions, and engine shutdown.

1 During normal engine startup operations, the GC switch is in the on position and the field relay is closed. The battery-external power switch is in the external power position and external ac power is connected to the ac tie bus. Each GR is open and the corresponding BTR is automatically closed through the closed contacts of the GR-4 and BTC-2. When conditions are satisfactory for closing the GR, and output signal from the US and TDR circuits will supply the base drive for transistor Q26 in the BTC circuit. The BTC relay picks up and the BTR is opened by grounding the trip coil through BTC-1 contacts. The GR closes and GRX is energized. After GRX-2 is closed, Q26 turns off. The BTC now remains energized through the contacts of the bus isolation (BI) relay. By placing the battery external power switch in the off posi-

tion, the BI relay contacts open and as the BTC relay for each system drops out, the BTC-2 contacts close. The close coil for the first BTR, which is selected by the preferential circuit, is energized through the BTC-2 contacts and the corresponding BTR closes. The other three bus tie relays cannot be closed until an output signal from the autoparalleling (AP) circuit indicates that conditions are satisfactory for paralleling the generators.

2 The GC switch can be used for BTC operation after the conditions required for closing the GR are satisfied, the bus fault lockout circuit is deenergized, and the battery-external power switch is placed in the battery position. The GC switch position determines the on and off state of Q25 which trips the BTR before the GR can close. When the GC switch is placed in the off position, the Q25 is on and VR22 input is clamped to ground through CR163. By placing the GC switch in the on position, VR23 input is grounded through CR160, Q25 is off, and CR163 is back-biased. The US and TDR output signal at the base of Q26 energizes the BTC relay. As a result, the BTR opens and the GR closes, energizing the GRX relay. The VR22 input is now grounded through CR167 and GRX-2, BTC relay Q26 turns off, and the BTR can again be closed.

3 The BTC circuit includes protection against UC and ZNS faults. Either fault condition can open the BTR and isolate the ac load buses. When triggered by the USTD output signal, Q26 energizes the BTC relay and opens the BTR for the faulted system. The ZNS output signal triggers SCR6, through Q27, and the BTC relay is energized. If ZNS is sensed in the ZNS/BFTD circuit, an output signal from SCR6 will energize the BTC relay through Q27 and the BFLO will prevent the BTC relay from deenergizing. The clamp imposed on the BFLO by SCR6 can be removed only by placing the BFR switch in the momentary reset position during specific operational procedures. A back-bias is then established at the base-emitter junction of Q27. Q27 is turned off, interrupting the current flow through SCR6, and the latch is removed from the BTC relay. If a fault still exists after the BFR switch returns to the normal position, another bus fault lockout condition will be triggered by the ZNS/BFTD circuit.

4 During normal shutdown procedures, the GRC relay is deenergized by the USTD circuit, the GR is tripped, and the BTR is closed through GR-4 contacts.

(o) The generator relay auxiliary (GRX) relay circuit functions during all modes of operation. During normal operations, the GR is closed and the GRX is energized through GR-5 contacts. If the tie bus is dead, the BTR is closed through GRX-1 and preferential sequence circuitry. The USTD is enabled by grounding CR121 through GRX-2. The BTC input is clamped by GRX-2 which locks out startup functions and the BTR trip function of the BI relay is enabled.

(p) The autoparalleled prevention (TO) circuit functions during paralleled operations. Q54 transistor operates as a switch to reflect the condition of the BTC through the normally closed contacts of BTC-1. When the BTC circuit is energized, the BTC-1 contacts open, Q54 is turned off, and the APL circuit is either deenergized or is prevented from being energized. The TO circuit locks out autoparalleling circuits which depend on the condition of the BTC relays and prevents other systems from being connected in parallel with a faulted system.

(q) The field relay control (FRC) circuit provides control of the field relay (FR) either through the VR/GC panel protection circuits or by the manual operation of the engine fire control handle. The latching-type FR has two coils, one for the trip function of the FR and the other for the reset function. Because of these separate functions, the two coils can never be energized at the same time. When one coil is energized, the other coil will be deenergized.

1 When operating conditions are normal and if no faults occur, SCR2 is in the off state. Although base drive for Q17 is available through R186, Q17 cannot be turned on while SCR2 is off. The only possible way to energize the FR trip coil is by manually operating the engine fire control handle during extreme emergency conditions.

2 If an OV, UV, or DP fault occurs, the output signal from the corresponding protection circuit will trigger SCR2 and Q17 emitter current will flow through Q17 and SCR2. The current is limited by the dc resistance of the trip coil and when the

voltage drip across the coil reaches 14 vdc, the FR is tripped and latched. The GRC relay drops out and after the GR opens, the GRX drops out and the BTR closes.

3 The FR can be reset by placing the GC switch in the reset position. If the fault which caused the tripping of the FR has been removed, 28-vdc power will be impressed across the FR reset coil. At the same time, Q13 is turned on with base current supplied through R54 and R55. When the voltage drop across the reset coil reaches 14 vdc, the FR closes. SCR1 is triggered through voltage divider R52 and R53. The voltage drop across SCR1 will put a back-bias on the base-emitter junction of Q13, latching SCR1 so that the FR will again trip if a fault occurs while the GC switch is held in the reset position. If the FR does not trip during the reset period, SCR1 will be turned off when the GC switch is released to the off position or placed in the on position.

(r) The overvoltage, undervoltage, and voltage regulator sensing (OUVRS) circuit consists of three single-phase stepdown transformers. The primary side of T1 tranformers is connected to the regulating sensing point for each phase located on the generator side of the GR. On the secondary side, the sensing signal is divided into two sensing circuits. The high-phase portion of the sensing output is connected to the input of the overvoltage and voltage regulator circuits. The average sensing circuit output is connected to the undervoltage circuit. Both sensing circuits are connected to ground through R89 and C9 in the RLD circuit. During paralleled operations, an under-excitation or over-excitation biasing signal is added to the OUVRS circuit output.

(s) The reactive load division (RLD) circuit controls reactive load division between generator which are operating in parallel . A current transformer equalizing loop within each current transformer and fuse box (CT/FB) senses the difference in reactive current carried by a generator and the average of reactive current carried by other generators. The current of each generator is sensed by current transformers connected to phase C of each generator. Since the four RLD current transformers are connected to form a loop circuit during paralleled operation, only the generators operating in parallel are affected by a signal from the corresponding current tranformers. If a GR or BTR for a particular generator system is tripped, the corresponding generator is not paralleled and the reactive load sensing current tranformer for that generator is shorted out. During paralleled operation, the reference signal obtained from phase A and B of the generator output is impressed across RLD circuit transformer T7. The input or sensing signal at transformer T8 is obtained from the CT/FB current transformer which senses the generator output of phase C. If the generator current in phase C is 90 degrees out-of-phase with the reference signal of phase A and B, the out-of-phase portion of the current will be rejected. The reactive portion of the current which is in phase with the reference signal will establish dc voltage across R91 and R89. This dc voltage is filtered by capacitor C9 and represents the reactive bias on the OUVRS circuit for the respective OV, UV, or VR circuit. Depending on the polarity of the bias signal, which is positive in the case of underexcitation and negative for overexcitation, the voltage regulator will change the field excitation in the appropriate direction to eliminate the reactive current unbalance. If the fault persists after changing the field excitation, the overexcitation or underexcitation actions will cause selective tripping of the faulted generator field relay through the RLD bias. With the faulted generator deenergized, the corresponding reactive load current transformer is shorted out and the RLD circuit output for the faulted system drops to zero.

(t) The overvoltage (OV) circuit provides protection against excessive generator output voltages. Voltages in excess of specified limits will cause a generator to be removed from the generator bus and the field excitation to be removed from the generator exciter field. Protection is accomplished on an individual phase basis with the highest of the three phases automatically selected for protection. Selective tripping for overexcitation faults of paralleled generators is provided by biasing the overvoltage limits with the reactive component of the circulating current.

1 When the generators are operating unparalleled, OV sensing is directly proportional to the generator output. With Q10 base-emitter junction reverse-biased, the collector voltage is approximately 16 vdc. This will reverse-bias Q11 base-emitter and prevent current flow through the collector of Q11. The voltage across C10 is zero and Q12 unijunction transistor is reverse-biased. There is no output from the OV circuit because

the generator output voltage is below the protective level of the OV circuit. If an overexcitation fault occurs and the generator output voltage rises, the output of the sensing circuit rises proportionately. When voltage at R40 reaches 7.5 volts, current starts to flow through Q10 base-emitter junction, turning Q10 on. When the voltage drop across R43 exceeds 0.5 vdc, Q11 is forward-biased. Q11 collector current starts charging capacitor C10 toward 16 vdc. As C10 voltage reaches 7 vdc, Q12 is triggered and C10 discharges rapidly through Q12 base-emitter junction and R49, which, in turn, triggers SCR2 of the FR trip coil. The FR trips, the GR opens, and the BTR closes.

2 When the generators are operating paralleled, the RLD circuit adds corrective signals to the sensing of the OV circuit. During normal system operation, the total reactive load is shared equally by all generators. If no fault occurs, the circulating current between generators is so low that the output of the reactive loop equalizer circuit is negligible and there is no output signal from the OV circuit. If an OV fault does not occur during paralleled operation, the RLD equalizer loop algebraically adds a negative dc signal to the output of the sensing which raises the voltage level at the center top of R40 above the reference level of VR10. Q10 starts to conduct and the rest of OV circuit operation will be the same as the operation for an unparalleled faulted system.

(u) The undervoltage (UV) circuit provides protection against sustained operation at low voltage. The average of the three-phase voltages is used to determine the voltage level. If a fault decreases the output voltage level to 89 (±3) vrms, the UV protection removes the generator from the bus and the excitation from the generator exciter field. If the voltage fails to rise above 104 volts during engine startup or after an undervoltage fault is removed, the GR cannot close. Selective tripping of paralleled generators for underexcitation faults is provided by biasing the undervoltage limits with the reactive component of the circulating current.

1 When unparalleled generator systems are operating normally, each generator should have reached the desired rpm and the output voltage and frequency should be within specified limits. When voltage adjustment potentiometer R58 is set, the volt-

age at the center tap is higher than the reference voltage level 6.8 volts set by VR12, and the collector voltage of Q14 is below the 12-volt breakdown level of VR14. Q15 is not energized and the collected voltage is 12 volts. The current flow through R65 drives both Q142 and Q152 into saturation. Q142 shorts out R60 which functions only during startup operations. Q152 is clamping the time delay network at approximately a one-volt level and provides a discharge path for capacitor C12. The low voltage of capacitor C12 keeps CR34 back-biased and, as a result, Q16 cannot be triggered. The voltage across R69 is zero during normal system operation. If a fault occurs, the voltage at the center top of R58 sinks below 6.8 volts and Q141 turns off. The voltage on Q14 collector increases to 12 volts, driving Q151 into saturation with the current flowing through R62 and turning both Q142 and Q152 off. The current flowing through R66 and R68 starts charing capacitor C12 toward a 16-vdc level. If Q16 is triggered within a 2- to 4-second time span, C12 discharges, through CR34 and Q16, and a 3-volt pulse is delivered across R69. The pulse triggers SCR2 in the FR trip coil circuit and the excitation is removed from the generator exciter field. When the GR opens, the BTR closes. If the UV condition disappears before Q16 is triggered, the UV circuit returns to a normal operating condition. The charging of capacitor C12 is interrupted and C12 discharges through R67 and Q152.

2 During normal paralleled operations, the RLD circuit is sensing any reactive current unbalance. Since the total reactive load is shared by paralleled systems, the RLD circuit output is negligible and does not affect the UV circuit. If a fault occurs, only the sensing portion of the UV circuit is affected. A positive signal algebraically added to the output of the average sensing will decrease the voltage level at the center top of R58. When this voltage is below the reference voltage level of VR12, Q141 turns off and a UV condition is established in the UV circuit. After a time delay of 2 to 4 seconds, the FR trips and opens the GR.

(v) The time delay reset (TDR) circuit disables the OV and UV time delay operation during normal engine startup and shutdown. The time delay circuits are locked out until generator speed and output voltage are within the specified limits.

1 During engine startup, the GR is open and the BTR is closed. If the FR is tripped by manual operation of the engine fire control handle, a double lockout will prevent operation of the OV and UV time delay circuits. One lockout is established by FR-1 contacts. The other lockout is through transistor Q9 which is turned on when the GRC lockout circuit is deenergizing. The dropout of the GRC relay will keep the GR open and, in turn, the BTC lockout will prevent the BTR from opening. Resetting the FR will remove the double lock from the OV and UV time delays but the TDR circuit will maintain the lock on the time delays and also on the GRC and BTC circuits until the speed and output voltage of the generator are within the specified limits. When the required conditions are satisfied, Q9 is turned off by the GRC lockout circuit and the OV and UV time delay lockout is removed. The GRC and BTC are energized, the BTR opens and the GR closes. During unparalleled or paralleled operations, the OV and UV can start timing out whenever the GRC relay is energized because the GRC-1 interlock will prevent Q9 from turning on. If an OV, UV, or DP fault occurs, the TDR is locked by FR-1 contacts before the GRC-1 interlock is removed from the GRC lockout circuit. If an US fault occurs, the GRC relay drops out and the GRC-1 interlock is removed. As soon as the GRC relay drops out, Q9 is turned on to prevent operation of the UV and OV time delay circuits.

2 When the US circuit is energized during normal shutodwn procedures, the USTD circuit starts to time out and the GRC lockout is turned off. The GRC relay is deenergized by the tripping of the USTD after a one-second time delay. When the GRC-1 interlock is removed, TDR Q9 turns on and clamps the UV and OV time delay circuits at a very low voltage level. The FR cannot be tripped by a UV or OV fault during engine shutdown.

(w) The differential protection (DP) circuit can trip the FR during any mode of operation. The DP circuit protects the generator from faults within the generator or from faults that can occur at any point in the power distribution system between the generator and the current transformer and limiter fuse box (CT/FB). The sensing portion of the DP circuit is a pair of current transformers connected back-to-back in each generator phase and in parallel with a burden resistor. If the current is the same in each pair of current transformers, there will be no signal across the resistor. If there is no output from any of the three pair of current transformers, the DP Schmitt trigger will be in a stable state; Q181 is on and Q182 is off. No FR trip can occur because the collector voltage of Q181 is below the breakdown level of VR16 and the voltage across R77 is zero. If, for instance, a line-to-ground fault occurs in phase A, the difference between currents, flowing through the two current tranformers, will flow through R80. The voltage drop across R80 is transferred by transformer T6 to a full-wave rectifier bridge. The output signal is filtered and if the level is high enough, Q181 turns off, raising the collector voltage level above the breakdown level of VR16. When zener diode VR16 is broken down, a signal appears at R77 and the FR trips.

(x) The underspeed (US) circuit disconnects the generator from the bus when the frequency is below the specified limits during single or unparalleled operating conditions. The protective function involves opening the GR relay after a one-second time delay. The USTD circuit is designed to operate with the underspeed sensor (USS) which is located on the case of the CSD tranmission. PM2 of the PMG is connected to one side of R187 in the US circuit. PM3 is connected to the other side of R187 through the USS. During low speed operation, the USS impedance is low and most of the line-to-line voltage is dropped across R187. When the output voltage picked up by transformer T10 is higher than 10.5 volts, CR125 is back-biased. The current flow through R189 and R188, which was charging C21, will now turn Q39 on. The collector voltage of Q39 will drop below the breakdown level of VR26, turning Q20 off. Capacitor C20 starts charging through R112, R113, and R110. As soon as the voltage level of C20 reaches the voltage level of Q21, SCR3 is triggered, the GRC relay drops out, the GR and GRX open, and the BTR closes. After the GRX relay is tripped, the ground is removed from the USTD circuit. As a result, the USTD circuit is disabled so that the GRC relay can be energized during normal startup operations. When the CSD output speed increases, the impedance of the USS increases and the voltage drop across R187 decreases. The voltage across C21 drops below 10.5 volts and Q39 starts to turn off. By the time the generator speed reaches 5700 rpm, most of the PMG voltage is being carried by the USS. Since only a small portion of the voltage is dropped across R187, Q39 is turned off completely.

Q20 turns on, clamping C20 at the one-volt level. The GRC relay can now be reenergized. The GR and GRX will close, re-establishing the ground on the USTD circuit.

(y) The zero-negative sequence (ZNS) circuit keeps the GR from closing if the phase sequence is incorrect or if an open feeder exists. A signal from the zero and negative sequence circuit prevents closing of the GRC relay if either of the conditions exist during startup and provides protection for equipment which is connected to the generator load bus.

1 The zero sequence portion of the circuit detects line-to-ground faults in the system and also detects open circuit where no motor loads are involved. During normal operation with equal voltages applied to phase A, B, and C; the voltage appearing across R140 will be zero. R140 connects the common junction point of the three phases to ground. If an unbalance in the applied voltages exists, the sum of the currents at the common junction point is no longer zero. Current will flow through R140 and provide an error voltage which is rectified and filtered to provide a dc signal to the base of Q432. Q432 and Q431 supply a reference level for the error signal. Q431 is normally on and establishes a voltage across R144. Q432 turns on when the base voltage exceeds the voltage level at the emitter of Q431. When turned on, Q432 will turn Q431 off. When Q431 is turned completely on, the voltage across R140 will be approximately 3 volts. The voltage at the collector of Q432 should be approximately 7 volts. With Q431 in a normal on state, more base drive is supplied at Q431 than is required to drive Q431 into saturation for the loads involved. Therefore, when the signal at Q432 base exceeds the emitter voltage, Q432 will start to turn on and the collector voltage starts to drop. As Q432 turns on more, the collector voltage decreases to a point where Q431 will suddenly turn off. When Q431 turns off, the collector voltage will jump from a 3-volt to approximately a 14-volt level and C47 will start to charge. Transistor Q44 is used in the time delay circuit to sense the capacitor voltage level. When the capacitor voltage reaches the peak voltage of the unijunction, Q44 will trigger and discharge the capacitor to produce a pulse at SCR6 in the bus

tie control circuit. SCR6 is turned on to provide a trip signal for the BTR and to provide a locking circuit that prevents the reclosing of the BTR.

2 The negative sequence portion of the circuit detects line-to-line faults in the system. This is accomplished with the primary-connected, open-delta, and secondary windings of T2 interconnected to provide a specific voltage relationship. One secondary is connected to a resistive load so that the current and voltage are in phase. The other secondary is connected to the resistor-capacitor network of R136, R167, R168, and C45 so that the current will lead the applied voltage by 60 degrees. The two secondary voltages are 120-degrees apart and the two currents are 180-degrees apart with a balanced input of the proper phase sequence. The error voltage is sensed across the two midpoints of the load and will be nearly zero for balanced inputs. If the phase sequence is changed from ABC to ACB. the V1 voltage will shift so that the currents are no longer 180-degrees apart and an error voltage will be developed across the load midpoints. The error signal is low ac voltage and a voltage doubler is used to provide rectification for the signal which is then applied to the Schmitt circuit. The voltage double circuit, consisting of C77, CR76, C44, and C48, will charge one capacitor to peak value during the first half-cycle and will charge the second capacitor to a peak during the other half-cycle so that the voltage at the output is twice the peak value of the applied voltage. Two clamping circuits are included. The Q432 base clamp is operated from the US circuit and will prevent Q43 from turning on when the system is operating at low speed. Since the impedance of the capacitor in the negative sequence circuit will vary with frequency, nuisance operation of the circuit which could occur during low speed operation is prevented. The time delay clamp is provided by the GRC relay or by the manual operation of the GC switch. With the GR relay open, nuisance bus fault lockouts are prevented. The signal from the collector of Q432 is used during startup to prevent an improper phase sequence from being connected to the load bus.

(z) The unbalanced current (UC) circuit senses the difference between the current in phase B of any generator and the average of the currents in phase B of the other generators. When the difference exceeds a preset amount, a signal will appear at the UC circuit output. The signal will trigger the time delay circuit which will energize the BTC relay after a 5- to 7-second time delay. When the BTC relay picks up, the BTR trip coil is energized through BTC-1 contacts, and the BTR will open.

1 During normal system operation, the output signal from R121 is picked up at the secondary of T11 and is rectified through a full-wave rectifier bridge. The signal is filtered by R120 and C40. When paralleled generators are sharing equal load, the circulating current between them is low. The UC output is connected to Q40 through R122. Q401 is normally in the off state because Q401 base-emitter junction is reverse-biased. As long as Q401 is off, Q402 is on. The low voltage of Q402 collector clamps C41 and C42, through CR87, at a voltage level that is below the voltage level required to trigger Q41. Q402 voltage level is also below the breakdown voltage level of VR40 which prevents Q42 from turning on and disconnects the source of power from SCR4 anode. The double safety feature of the Q402 transistor is essential to prevent the UCTD triggering SCR4, during transient current conditions, when a generator is connected to the ac tie bus through the autoparalleling circuit. Any current transient higher than 24 amperes can trigger Q40. In turn, Q401 turns on and Q402 turns off. The collector voltage of Q402 is high enough to break down VR40 and Q42 turns on, connecting power to the anode of SCR4. At the same C42 start to charge through R124 and R130. If the unbalanced condition exists longer than 5 seconds, the voltage level for triggering Q41 is reached, and the pulse delivered charge of C41 and C42 across R132 will trigger SCR4. The voltage across R134 will trigger Q26 in BTC circuit, energizing the BTC relay and tripping the BTR. After the BTR is tripped, the UC current transformer is shorted out by the BTR-1 contacts. The UC circuit output drops to zero, Q40 returns to a stable state condition, the time delay capacitors are clamped, and the current flow through SCR4 is interrupted because Q42 has turned off.

(aa) The ac generators can be paralleled when the autoparallel (AP) circuit senses that all conditions for safe paralleling have been satisfied. The AP system is armed by momentarily pressing the generator parallel switch. After BTR is closed by the preferential circuit, the corresponding generator is connected to the ac tie bus. The BTR for each of the the remaining generators is automatically closed by the AP circuit when the generator voltage and tie bus voltage difference is 20 volts or less and the frequency difference is 8 cps or less. Paralleling cannot occur unless the battery-external power switch is in the battery position and the ac bus isolation switch is in the normal position. Any operating condition which can cause a BTR to open will also disarm the AP system.

1 The generator output on phase A is connected to the primary coil of T2 in the AP circuit. The low side of the coil is connected to APL-1 and APL-2 contacts through two blocking diodes, CR104 and CR105. During unparalleled operations, the autoparallel lockout (APL) relay in the bus protection panel (BPP) is deenergized and APL-1 and APL-2 contacts are open. The sensing signals from other generator systems are inhibited by CR104 and CR105. Most of the line-to-ground voltage of the generator is being carried across R231 while the remaining voltage is impressed across T2. The ac voltage across T2 is stepped down and rectified to charge C50 and drive transistor Q51. Up to this point, Q51 has been driven with 28-vdc control power, through Q50, to keep Q51 collector voltage at a low level. While ac voltage is applied on the coil of T2, the ac lockout portion of the AP circuit is energized with the positive half-cycle of the generator frequency. Each time Q521 turns on, Q50 turns off, and Q51 is driven by the intermittent signal from the rectifier bridge output. Every positive half-cycle of the frequency turns Q521 on and the negative half-cycle turns Q521 off. Q50 is turned on or off according to the state of Q521. The base-emitter junction of Q522 is reverse-biased, preventing current from flowing through Q52. As a result, Q53 is off and SCR5 will not receive a paralleling signal. Since there is no output signal from the AP circuit to energize the BTR close coil, the generators cannot be paralleled.

2 After the generator parallel switch is pressed, the APL relay is energized and APL-1 and APL-2 contacts close. With the AP system armed, the output on phase A for the first generator to be connected to the ac tie bus is applied to the primary coil of T2. If conditions required for paralleling are satisfied,

the output of the bridge rectifier sinks below the C50 voltage level and C50 starts to discharge through the base-emitter junction of Q51 and R230, R153, and R169. When the discharge current of C50 is too low to drive Q51, the collector voltage of Q51 rises above the breakdown level of VR52 and Q522 turns on. SCR5 is triggered by the pulse at the collector of Q53. The BTR close coil is energized and the generator is connected to the ac tie bus. When the generators are operating in parallel, no voltage is carried across the sensing transformer, and the pulse at the collector of Q53 should be the same as the output frequency of the paralleled generators.

I. To Operate System

(1) General

(a) Operation of the system includes electrical procedures to be followed when starting an engine, or engines, with external AC power supplied to the AC buses and with battery or DC external power supplied to the DC buses.

(b) For information on applying AC external power to the AC buses, see 24-40-0, Description and Operation.

(c) The frequency meter does not have a zero indication marked on the scale. When a procedural step states that the frequency meter should indicate zero, the frequency meter pointer should be on the dot at the lower end of the scale.

(d) The master warning light may come on at various points in the procedures. The light should be reset immediately before proceeding with the next procedural step.

(2) Electrical Procedures - starting Engine with AC External Power Supplied to Buses

CAUTION: DO NOT ALLOW ANY GENERATOR LOAD TO EXCEED 1.0.

NOTE: To start a single generator, perform steps 1 through 5, substituting the applicable generator number.

Procedures	Indications
(1) Check that battery-external power switch is in external power position.	Four generator unparalleled and four generator drive oil lights should be on. Four DC loadmeter indicators should indicate some load.
(2) Check that all recirculating fan switches are in off position.	There should be no change.
(3) Place four generator control switches in on position.	There should be no change.
(4) Place voltage and frequency selector switch in the AC tie position.	AC voltmeter indicator should indicate approximately 115 volts; frequency meter indicator should indicate approximately 400 cycles.

Procedures	Indications
(5) Place voltage and frequency selector switch in No. 3 generator position. Start No. 3 engine (see Chapter 71).	When engine speed increases, No. 3 generator drive oil light should be off, and AC voltmeter indication should increase. frequency meter indication should also increase. Voltmeter should stabilize at 115 volts before frequency meter indication reaches 400 cycles. The AC loadmeter for No. 3 generator should indicate some load (No. 3 bus load has transferred from external power to No. 3 generator), frequency meter should stabilize at 400 cycles, No. 3 generator drive transmission oil temperature indicator should slowly increase and stabilize in normal range (below yellow band).
(6) Place voltage and frequency selector switch in No. 4 generator position. Start No. 4 engine (see Chapter 71).	No. 4 indications should be same as No. 3.
(7) Place voltage and frequency selector switch in No. 2 generator position. Start No. 2 engine (see Chapter 71).	No. 2 indications should be same as No. 3.
(8) Place voltage and frequency selector switch in No. 1 generator position. Start No. 1 engine (see Chapter 71).	No. 1 indications should be same as No. 3. Four generator unparalleled lights should be on.
(9) Place the battery-external power switch in battery position.	No. 2 generator unparalleled light should be off. Other three lights should stay on. External power available light should be on. External power not in use light should come.

NOTE: Steps 10 through 14 check preferential circuit.

Procedures	Indications
(10) Place No. 2 generator control switch in off position.	No. 2 generator unparalleled light should be on and No. 3 generator unparalleled should be off. No. 2 AC loadmeter should indicate zero No. 3 AC loadmeter indication should increase.
(11) Place No. 3 generator control switch in off position.	No. 3 generator unparalleled light should be on and No. 1 generator unparalleled light should be off. No. 3 AC loadmeter should indicate zero and No. 1 AC loadmeter indication should increase. Do not allow affected AC loadmeter to exceed 1.0 (GND) for more than 1 minute. If load exceeds 1.0, generator overload light should be on.
(12) Place No. 1 generator control switch in off position.	No. 1 generator unparalleled light should be on and No. 4 generator unparalleled light should be off. No. 1 AC loadmeter should indicate zero and No. 4 AC loadmeter indication should increase. Do not allow affected AC loadmeter to exceed 1.0 (GND) for more than 1 minute. If load exceeds 1.0, generator overload light should be on.
(13) Place No. 1, 2, and 3 generator control switches in on position.	No. 1, 2, and 3 AC loadmeters should indicate load and No. 4 AC loadmeter indication should decrease. There should be no change in generator unparalleled lights.

Procedures	Indications
(14) Place No. 4 generator control switch in off position and then in on position.	No. 4 generator unparalleled light should be on and No. 2 generator unparalleled light should be off.
(15) Momentarily press and release generator parallel switch.	Three generator unparalleled lights that were on should be off. Four generators are now paralleled. Voltage and frequency should be same for all four generators. Four AC loadmeters should indicate approximately the same.
(16) Place recirculating fan switches to desired position.	AC loadmeters should show an increase if loads are turned on.
(17) Disconnect external electrical power supply.	External power available light should be off.

(3) Electrical Procedures - Starting Engines with DC Power supplied to Buses

CAUTION: DO NOT ALLOW ANY GENERATOR LOAD TO EXCEED 1.0

NOTE: These procedures assume that the order in which the engines be started is 3-4-2-1. The procedures also apply to any other starting order in which engine No. 3, or 4, is started first, provided appropriate changes are made in each engine number, generator number, and in the corresponding controls number. When battery power is used, the switch should be in the battery position.

Procedures	Indications
(1) Check that recirculating fan switches are in off position.	
(2) Place voltage and frequency selector switch in battery position.	When airplane battery is used and battery-external power switch is in battery position, DC voltmeter should indicate approximately 24 volts. When DC external power is used and switch is in external power position, DC voltmeter should indicate zero, and all generator unparalleled, bus power fail, and emergency bus power fail lights should be on. All other indicating lights should be off. All loadmeters should indicate zero.
(3) Place No. 1 and 2 emergency electrical control switches in bus power off position.	There should be no change.

Procedures	Indications
(4) Place voltage and frequency selector switch in No. 3 generator position.	AC voltage and fequency should be zero.
(5) Start No. 3 engine (see Chapter 71).	When engine speed increases, AC voltmeter and frequency meter indications should increase. Voltmeter should stabilize at approximately 115 volts before frequency meter indicates 400 cycles. No. 3 AC loadmeter should indicate some load. No. 3 generator unparalleled light and No. 3 bus power fail light should go off. Right and left emergency bus power fail lights should be off. Frequency meter should stabilize at approximately 400 cycles.
(7) Place voltage and frequency selector switch in No. 4 generator position.	AC voltage and frequency should be zero.

Procedures	Indications
(8) Start No. 4 engine (see Chapter 71).	No. 4 engine indications should be same as No. 3, except that No. 4 generator unparalleled light remain on. No. 4 AC loadmeter indication should increase and No. 3 AC loadmeter indication should decrease. No. 4 generator drive oil light should be off and indication on No. 4 generator drive transmission oil temperature indicator should slowly increase and stabilize in normal range (below yellow band).
(9) Place No. 2 emergency electrical control switch in bus power normal position.	No. 3 AC loadmeter indication should increase, and No. 2 bus power fail light should be off.
(10) Place voltage and frequency selector switch in No. 2 generator position.	AC voltage and frequency be zero.
(11) Start No. 2 engine (see Chapter 71).	Indication for No. 2 engine should be same as No. 3, except that No. 2 generator unparalleled light should remain on. No. 2 AC loadmeter indication should increase, and No. 3 AC loadmeter indication should decrease.

Procedures	Indications
(12) Place No. 1 emergency electrical control switch in bus power normal position.	No. 3 AC loadmeter indication should increase, and No. 1 bus power fail light should be off. No. 1 generator drive oil light should come on and No. 2 generator drive transmission oil temperature indicator should increase slowly and stabilize in normal range (below yellow band).
(13) Place voltage and frequency selector switch in No. 1 generator position.	AC voltage and frequency should be zero.
(14) Start No. 1 engine (see Chapter 71).	No. 1 engine indications should be same as No. 4, except that No. 1 generator drive oil light should be off and No. 1 generator unparalleled light remains on. No. 1 AC loadmeter indication should increase, and No. 3 AC loadmeter indication should decrease.
(15) Place No. 3 generator control switch in off position and then in on position.	No. 3 generator unparalleled light should be on and No. 2 generator unparalleled light should be off.
(16) Place battery-external power switch in battery position.	There should be no change.

NOTE: Steps 17 through 21 check preferential circuit.

Procedures	Indications
(17) Place No. 2 generator control switch in the off position.	No. 2 generator unparalleled light should come on and No. 3 generator unparalleled light should be off. No. 2 AC loadmeter should go to zero, and No. 3 AC loadmeter should increase.

Procedures	Indications
(18) Place No. 3 generator control switch in off position.	No. 3 generator unparalleled light should come on and No. 1 generator unparalleled light should go off. No. 3 AC loadmeter should go to zero. No. 1 AC loadmeter should increase. Do not allow affected AC loadmeter indication to exceed 1.0 (GND) for more than 1 minute. If load exceeds 1.0, generator overload light should be on.
(19) Place No. 1 generator control switch in off position.	No. 1 generator unparalleled light should come on and No. 4 generator unparalleled light should go off. No. 1 AC loadmeter should go to zero, and No. 4 AC loadmeter should increase. Do not allow affected AC loadmeter indication to exceed 1.0 (GND) for more than 1 minute. If load exceeds 1.0, generator overload light should be on.
(20) Place No. 1, 2, and 3 generator control switches in on position.	No. 1, 2, and 3 AC loadmeters should indicate load, and No. 4 AC loadmeter indication should decrease. There should be no change in generator unparalleled lights.
(21) Place No. 4 generator control switch in off position and then in on position.	No. 4 generator unparalleled light should come on and No. 2 generator unparalleled light should go off.

Procedures	Indications
(22) Momentarily press and release generator parallel switch.	Three generator unparalleled lights which were on should be off, indicating that four generators are paralleled. Voltage and frequency should be same for all four generators. Four AC loadmeters should indicate approximately same.
(23) Place recirculating fan switches to desired position.	AC loadmeter should show an increase if loads are turned on.

5. Auto Parallel (See Figure 24-36)

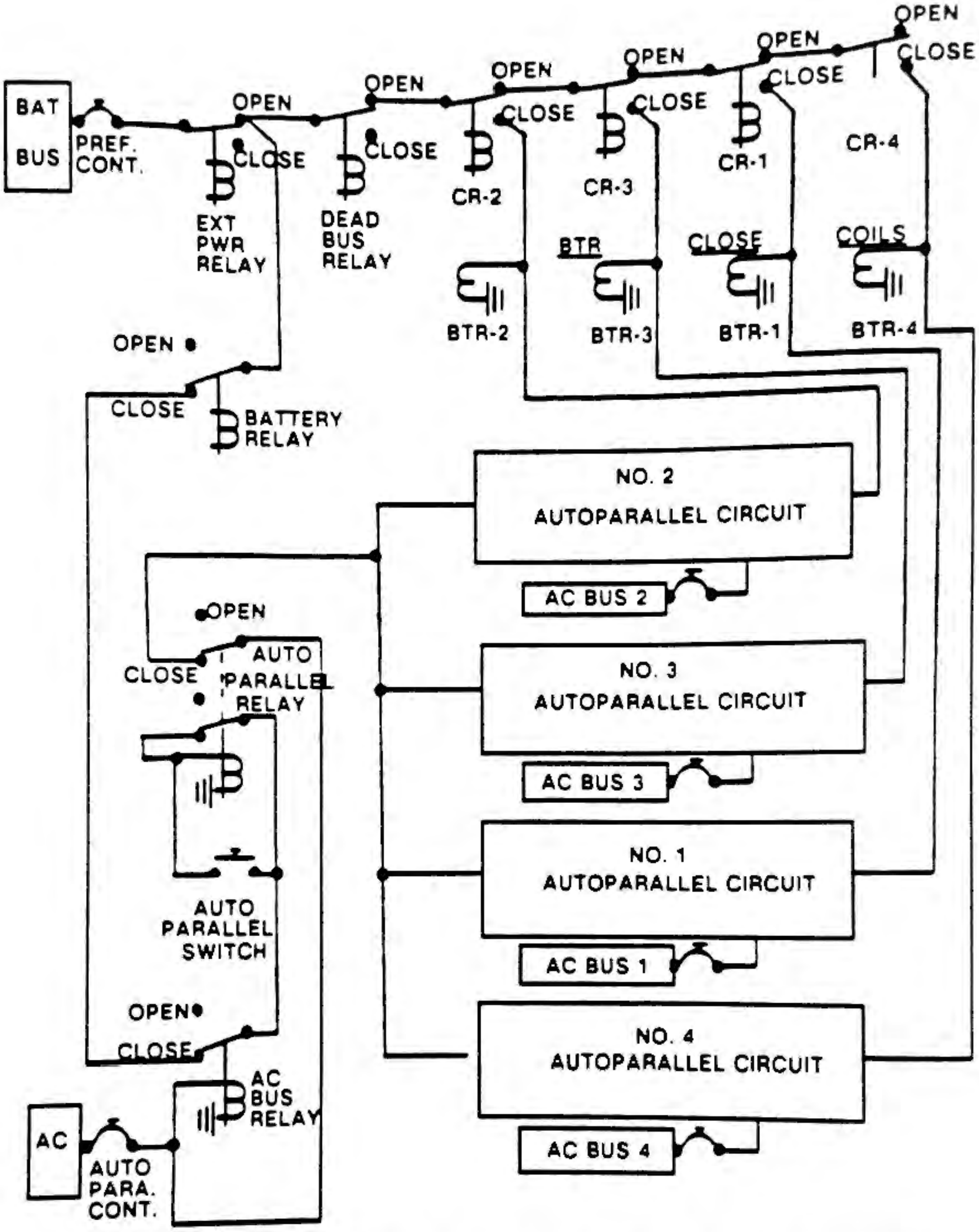
The four generator systems can be operated paralleled or unparalleled. Parallel operations is preferred, as it allows the generators to share the total electrical load. To parallel the generators, the battery-external power switch must be in the BATT position and the generator parallel switch depressed momentarily. The BATT position is the normal in-flight position of the battery-external power switch which causes the battery relay to be energized. This assures that the battery will be charged during flight and adequate d-c voltage is available to the electrical system protective circuitry should an a-c fault occur. The autoparallel circuit is completed through one normally open set of battery relay contacts. Momentarily depressing the generator parallel switch energizes the APL from the 28-volt, d-c battery bus through the No. 1 EPR and four TO's. The APL maintains a self-holding circuit through one of its own contacts. Through two other sets of contacts of the APL a circuit is completed from the ac tie bus to one side of each of four rectifier bridges. The other side of each of the bridges is connected to phase A of its generator. Any voltage across the rectifier bridge due to phase difference between the generator and the tie bus voltage will energize the APS. A condenser connected in series with a blocking rectifier through the APS contacts will then receive a charge equal to the voltage difference between the generator bus and the a-c tie bus. The maximum voltage difference will occur when the generator and the tie bus are 180 degrees out of phase. When the generator and bus tie voltages drift into phase, the APS will deenergize. The charged capacitor will now discharge through the coil of the AP, momentarily closing its contacts. This completes the BTR close circuit through the TO and BTR normally closed contacts to close the BTR, paralleling the generator. The remaining generators are paralleled in the same manner. The generator unparalleled lights go off as each generator is paralleled. There's no definite sequence or time involved in which the generators will parallel when the auto-parallel system is put into operation.

6. Preferential Circuit

In review, it will be remembered from preceeding paragraphs that before engine start-up, when a generator is inoperative, the associated bus tie relay is closed and the generator relay is open. When the engine is started and its generator becomes operative (control switch ON), the bus tie relay opens and the generator relay closes.

A. During unparalleled operation, continuity of service is assured for all loads by automatic control of the bus tie relays. That is, if a generator fails, whichever operative generator is first in the order of No. 2-3-1-4 connects to the ac tie bus to take over the load of the generator bus that has lost power. Although this sequence was chosen during the design of the system, it has no great significance. However, there is a slight advantage in having No. 2 and 3 as the first two in that the two ac emergency busses are connected to No. 2 and 3 generator busses.

B. When operating unparalleled, there is always one of four generators (usually No. 2) connected to the ac tie bus, which requires that the associated bus tie relay be closed. Then, if a generator fails, its bus tie relay closes automatically and connects the dead generator bus to No. 2 generator (if available) via the ac tie bus. The generator that is to assume the additional load is selected automatically by a preferential circuit. An understanding of this simple circuit, shown schematically in figure 24-36, will be of considerable value to personnel who either operate or maintain the system.



PREFERENTIAL AND AUTO PARALLEL CONTROL

FTX80041

Figure 24-36

C. During paralleled operation, at which time all generators are connected to the ac tie bus, the preferential circuit is not needed and is inoperative. During unparalleled operation, however, it automatically provides continuity of service to all load busses even if only one generator is operating. From figure 24-36 it is apparent that for the preferential circuit to be operative, the generator preferential control circuit breaker (located on the battery bus section of the circuit breaker panel) must be closed, and NO. 1 external power relay must be open (preferential circuit contact closed). The battery-external power switch should bein the BATT position. Upon loss of voltage on the ac tie bus, the dead bus relay opens (preferential circuit contact closes) and applies dc voltage to the preferential circuit. The following examples will assist in an understanding of the circuit:

(1) Assume an engine start-up with ac external power is in progress; No. 3 and 4 engines are already running and No. 3 and 4 generator relays are closed, thus connecting the generators to their respective busses. The ac tie bus and No. 1 and 2 generator busses are still being energized by external power. By placing the battery-external power switch in the BATT position, the No. 1 external power relay is opened and the ac tie bus is de-energized. The dead bus relay opens (preferential circuit contact closes) and applies dc control voltage to the preferential circuit. No. 2 generator is first in the preferential order, but it is inoperative and its generator relay is tripped; so, the control is passed on to No. 3 (see figure 6). Since No. 3 generator is operating and its generator relay is closed, control power is fed to the closing coil of No. 3 bus tie relay. This action re-energizes the ac tie bus, closes the dead bus relay (the preferential circuit contact opens), and removes contorl power from the preferential circuit. No. 3 generator is now carrying the load of its own bus, plus that of generator busses No. 1 and 2. GEN UNPARL'D light No. 3 will go "off", but No. 1, 2 and 4 will stay "on".

(2) If No. 1 engine is started next, its generator comes up to speed and voltage, and the generator contorl switch is placed in the ON position. This trips No. 1 bus tie relay; No. 1 generator relay closes and No. 1 generator picks up the load of its own bus. The GEN UNPARL'D lights do not change; NO. 3 is "off", the others are "on". When No. 2 engine is started, the same sequence of events takes place as when No. 1 was started, and the GEN UNPARL'D lights do not change.

(3) If all four engines have been started before turning the battery-external power switch to the BATT position, all GEN UNPARL'D lights would have remained "on" until the external power was discontinued, at which time the No. 2 light would have gone "off" and the others would remain "on".

D. Generating System Control Panel Display During Unparalleled Operation

(1) The display shown in figure 24-37 is typical of an unparalleled system in which all four generators are operating normally. The GEN UNPARL'D lights being "on" for No. 1, 3, and 4 generators, but "off" for NO. 2 generator, indicates that No. 1, 3 and 4 bus tie relays are open and No. 2 is closed. There is load indicated on all four ac loadmeters, so all four generator relays must be closed. With No. 2 bus tie relay closed, the ac bus tie is being energized by No. 2 generator.

(2) If one or all of No. 1, 3 and 4 generators should fail, there would be no change from the light display shown in figure 7. However, there would be a change in the ac loadmeter readings because No. 2 generator would automatically pick up the load of the failed generators. If only one generator should fail, the load on No. 2 generator increases but - under most flight conditions - would not become an overload. Nevertheless, the condition must be carefully monitored. If two generators should fail, the load no No. 2 generator is apt to become excessive. Then it is necessary to put the two operating generators in parallel, or reduce the load on the generator that is overloaded. If three generators should fail, it is almost certain that No. 2 generator would become overloaded and the GEN OVERL'D light would come "on". Then the load on No. 2 generator must be reduced to the point on its loadmeter marked GND or FLT (depending on the type of operation) by switching "off" nonessential loads. One generator has sufficient capacity to carry all essential loads.

(3) If the number of generators available makes load reduction necessayr, the recirculating fan and the galley are large nonessential loads that are easily turned "off". It should be noted that even if the recirculating fans are not operating at a particular time, the control circuits of the fans allow them to start from some unassociated action such as the turning "off" of a cabin compressor (two compressors on some airplanes), or when the airplane is landed and the nose oleo compresses. This can be prevented by placing the recirculating fan switches in the OFF position.

(4) The maximum allowable continuous generator load during ground operating is its nominal name plate rating (20 or 30 kva, whichever is the generator rating); in flight, it is 137% of this rating. These points are marked on the ac loadmeters as 1.0 (GND) and 1.37 (FLT), respectively. (The difference in available cooling air accounts for the two ratings). The GEN OVERL'D light is automatically recalibrated to reflect these two ratings.

(5) If No. 2 generator should fail during operation with the panel condition displayed in figure 24-37, its generator relay would trip but its bus tie relay would not trip. No. 3 bus tie relay would close immediately and pick up the load of No. 2 bus. The GEN UNPARL'D light of No. 2 generator would come "on", and that of No. 3 would go "off". Then No. 3 generator functions the way No. 2 did previously. If No. 3 should fail with No. 2 also inoperative, No. 1 takes over. If No. 1 should fail subsequently, No. 4 carries the entire load.

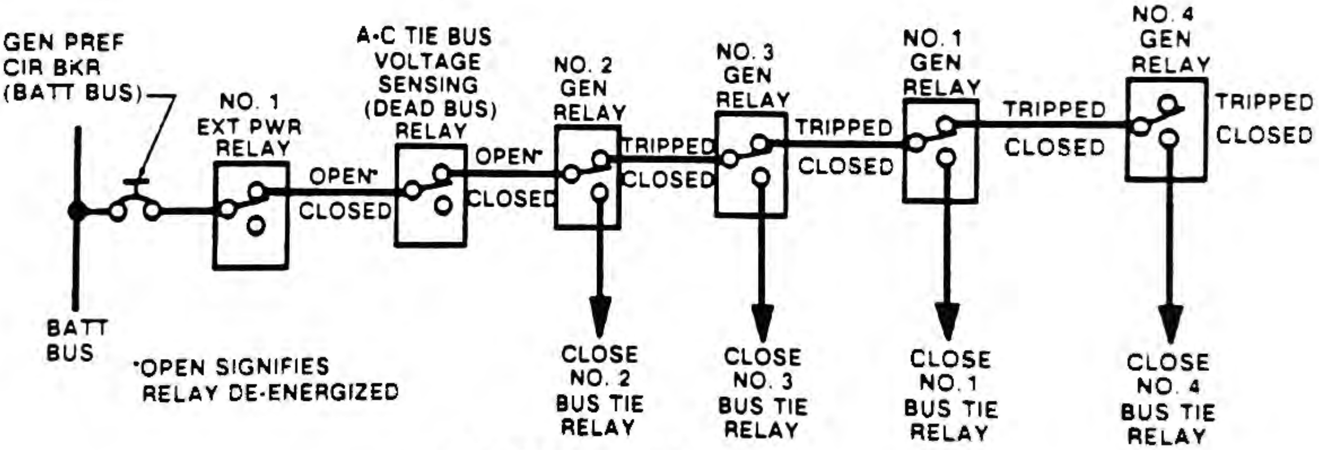
E. Preferential Circuit Check

(1) Prior to take-off, the preferential circuit should be checked as outlined in the DC-8 Operation Manual. Prior to performing the preferential circuit check, the load on the generators should be reduced by turning "off" the recirculating fans and the galley loads. The check consists of turning "off" the generator that is energizing the ac tie bus (the one with it GEN UNPARL'D light "off"), then noting that another generator immediately connects to the ac tie bus, as evidenced by its GEN UNPARL'D light going "off". The light which was "off" should come "on".

(2) As previously noted, the GEN UNPARL'D light that goes "off" when the battery-external power switch is placed in the BATT position depends upon which generators are operating at the time. If all four are in operating, No. 2 light goes "off"; if No. 2 is not operating but No. 3 and 4 are, then No. 3 light goes "off".

(3) Before removing the external power plug, it is important that external power be turned "off" by placing the battery-external power swithc in the BATT posiiton. This is especially ture if only one or two generators are operating; under this condition, unless the switch is in the BATT position before the external power plug is removed, the battery bus and some of the other dc busses may become de-energized. thus removing contorl power from the preferential circuit. This could cause

a partial power loss on some of the ac busses. In this event, power could be restored by placing the battery-external power switch in the BATT position.



PREFERENTIAL CIRCUIT

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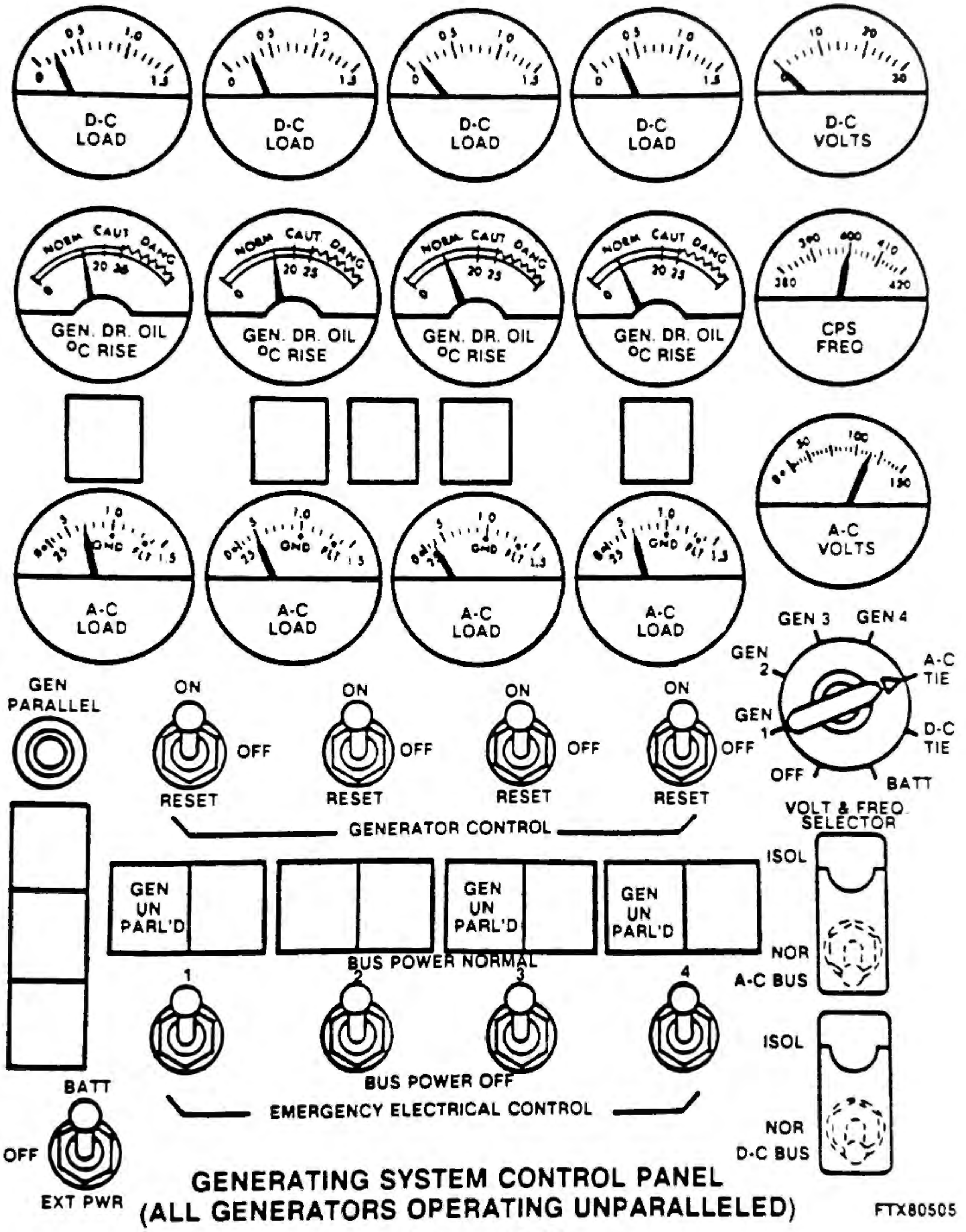
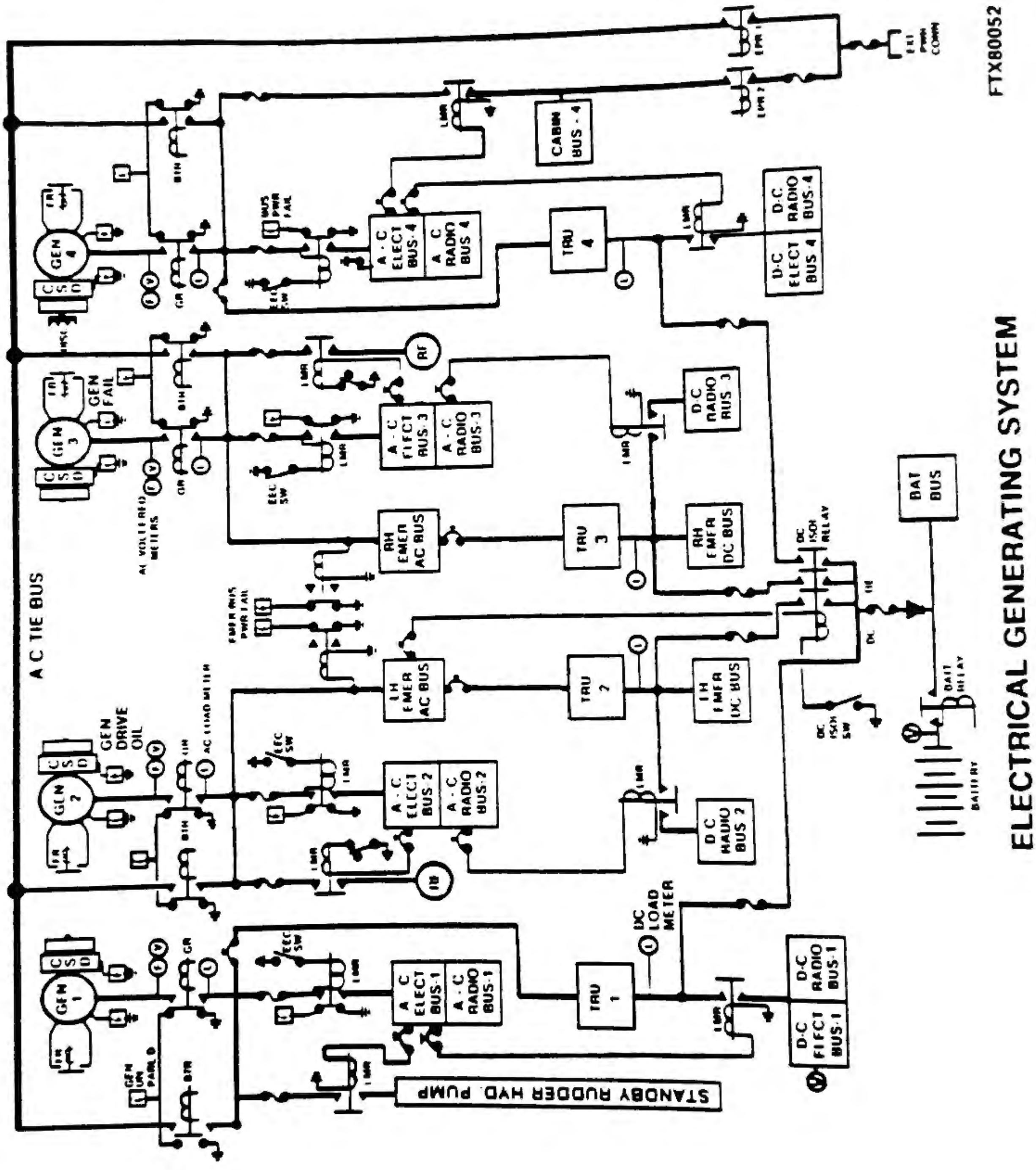
Figure 24-37



GENERATING SYSTEM CONTROL PANEL
(ALL GENERATORS OPERATING UNPARALLELED)

FTX80505

Figure 24-38



ELECTRICAL GENERATING SYSTEM

Figure 24-39

7. DC Generation - Description and Operation

F. General (See Figure 24-39)

The DC power required to operate the airplane equipment is supplied by four transformer-rectifier units located aft in the air-conditioning compartment and a battery located forward in the right main gear wheel well. Distribution of DC power is accomplished through load monitoring relays and an DC isolation relay located in the electrical power center. Controls and indications for monitoring and controlling DC power are located on the upper left section of the systems engineer's control panel.

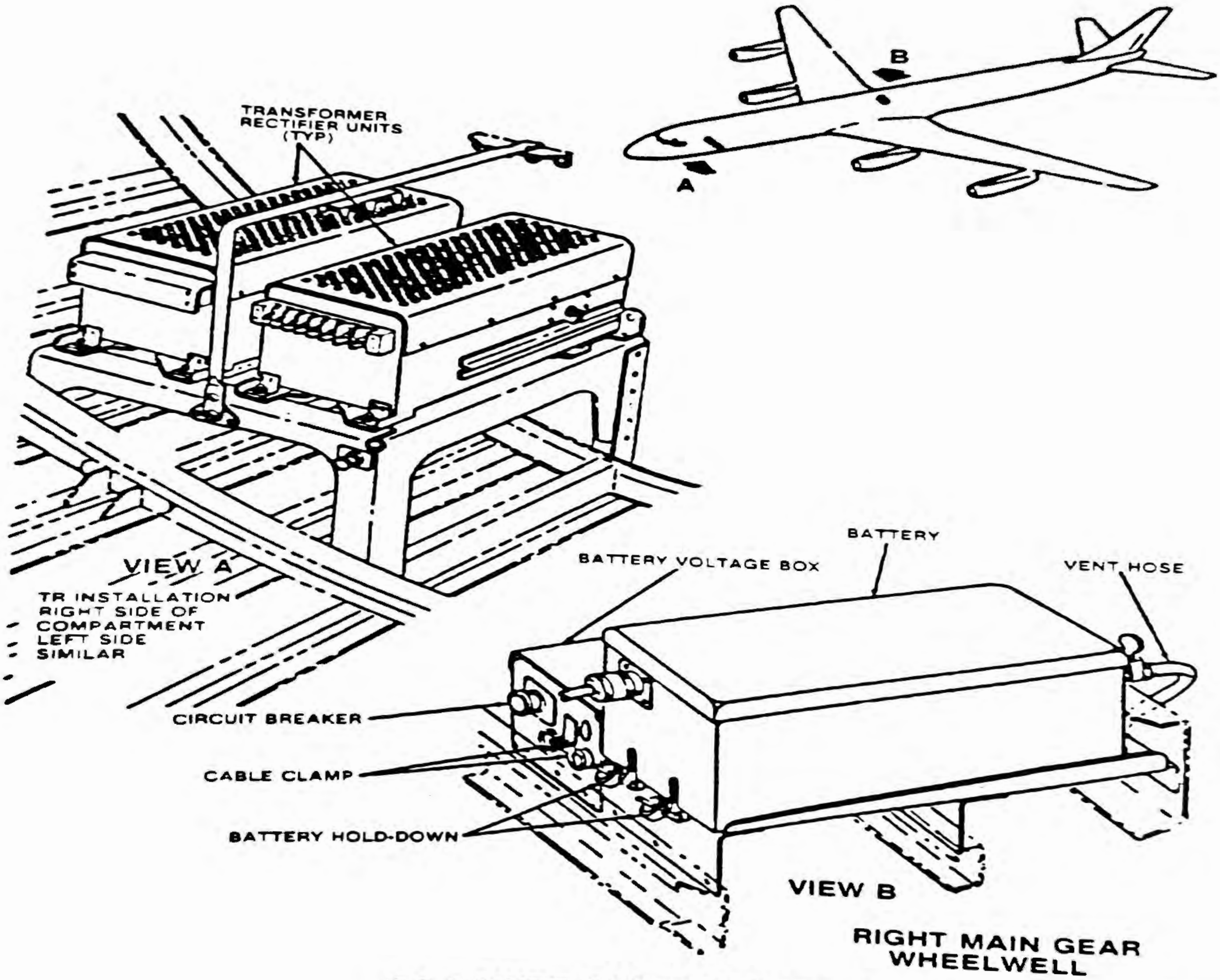
G. Controls and Indications

(1) DC Loadmeters

Four DC loadmeters, one for each transformer-rectifier, indicate output current proportional to the rate of the respective transformer-rectifier. The loadmeters are calibrated in rated load from 0 to 1.5 and the indication should not exceed 1.3. The DC loadmeter can indicate different loads during normal opration, but each should show some load. Load is also indicated when AC external power is applied to the load buses.

(2) DC Voltmeter

A DC voltmeter indicates the DC voltage at the battery when the voltage and frequency selector switch is in the battery position. The voltmeter indicates the DC tie bus voltage when the switch is in the DC tie position. With the voltage and frequency selector switch in the DC tie position and the DC bus isolation switch in the isolate position, the DC voltmeter indicates the output voltage of No. 1 transformer-rectifier only. The DC voltmeter is calibrated in volts from 0 to 30. The indication should be from 25 to 29 volts during external power or generator operation and should not be less than 24 volts during battery operation.


B
A
TRANSFORMER RECTIFIER UNITS (TYP)
VIEW A
TR INSTALLATION RIGHT SIDE OF COMPARTMENT LEFT SIDE SIMILAR
BATTERY
BATTERY VOLTAGE BOX
VENT HOSE
CIRCUIT BREAKER
CABLE CLAMP
BATTERY HOLD-DOWN
VIEW B
RIGHT MAIN GEAR WHEELWELL

DC POWER SYSTEM INSTALLATIONS

FTX80042

Figure 24-40

(3) Voltage and Frequency Selector Switch

An 8-position, rotary switch selects the indications on the AC voltmeter, frequency meter, and DC voltmeter. When the switch is in the off position, all three meters are deenergized. With the switch in any one of the four generator positions, the frequency and AC voltage of the corresponding generator is indicated on the frequency meter and AC voltmeter. In the AC tie position, the frequency and voltage of the AC tie bus is indicated on the corresponding meters. In the DC tie position, voltage applied to 28-vdc bus 1 is indicated on the DC voltmeter provided the 115/200-vac bus 1 is energized. Battery voltage is indicated on the DC voltmeter when the voltage and frequency selector is in the battery position.

(4) DC Bus Isolation Switch

A DC bus isolation switch is in a guarded normal position during normal operation and all four transformer-rectifiers are connected to the DC tie bus. When the switch is placed in the unguarded isolate position, the No. 2, 3, and 4 transformer-rectifiers are disconnected from the DC tie bus. No. 1 transformer-rectifier remains connected to the DC tie bus.

(5) Battery-External Power Switch

A 3-position battery-external power switch is normally lever-locked in the battery position. For all flight operations, the switch is in the battery position to connect the airplane battery to the battery bus. When the switch is in the off position, the battery is disconnected from the battery bus and no external power is connected to the AC tie bus. Placing the switch in the external power position connects an AC external power supply to the AC tie bus. If a DC external electrical power supply is used, only the battery bus is energized and the airplane battery is disconnected from the battery bus.

H. Component Description (See Figure 24-40)

(1) Transformer-Rectifier Units

(a) Four 50-ampere, unregulated transformer-rectifier units are used to convert AC to DC and to lower the voltage. The input is 115/200 volt, 3-phase 400-cps, AC power. The output of each transformer-rectifier supplies 28-vdc power to the respective DC load buses and to the DC tie bus. The transformer-rectifiers supply power to their respective load buses through corresponding load monitoring relays. In addition, the No. 2 and 3 transformer-rectifiers supply power to the left and right DC emergency buses, respectively. DC power is supplied to the DC tie bus directly from No. 1 transformer-rectifier and through an isolation relay from No. 2, 3, and 4 transformer-rectifiers. The ground return of each rectifier is connected through an 80-ampere, 50-millivolt shunt which is contained in the case and is used in the DC loadmeter circuit.

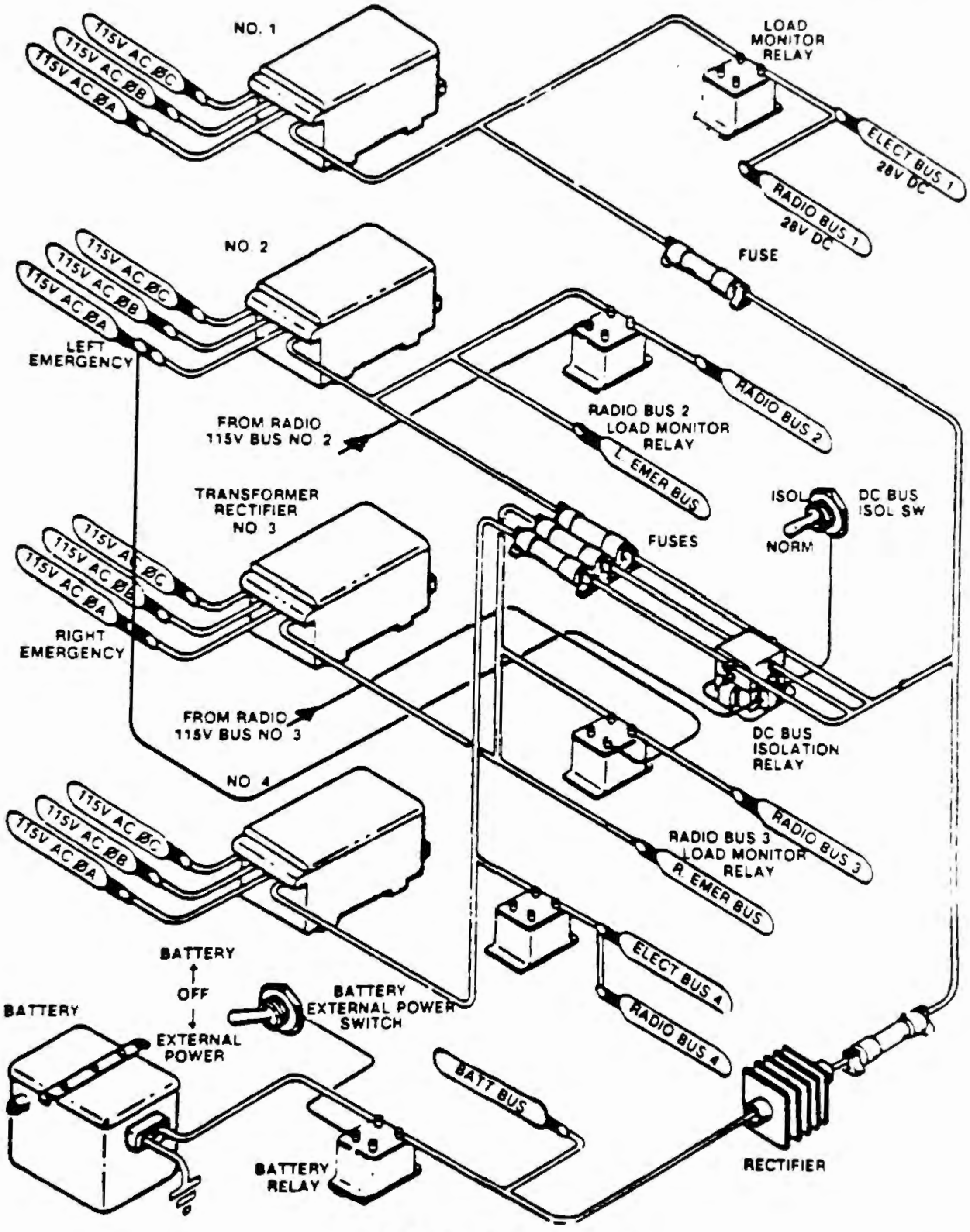
(2) Blocking Rectifier Assembly

During normal operation, the DC tie bus supplies power to the battery bus through a blocking rectifier. The blocking rectifier is located between the DC tie bus and the battery and battery bus. When the DC tie bus is energized, power is supplied to the battery bus through the blocking rectifier. Power is also supplied to the battery for recharging purposes, provided the external power switch is in the battery position. The blocking rectifier permits the battery to receive charging current when the DC tie bus is powered and prevents the battery from discharging into the loads connected to the DC tie bus when the DC tie bus is deenergized.

(3) Battery (See Figure 24-41)

(a) A 10-ampere hour, 24-volt, nickel-cadmium battery supplies DC power to the battery bus through a battery relay.

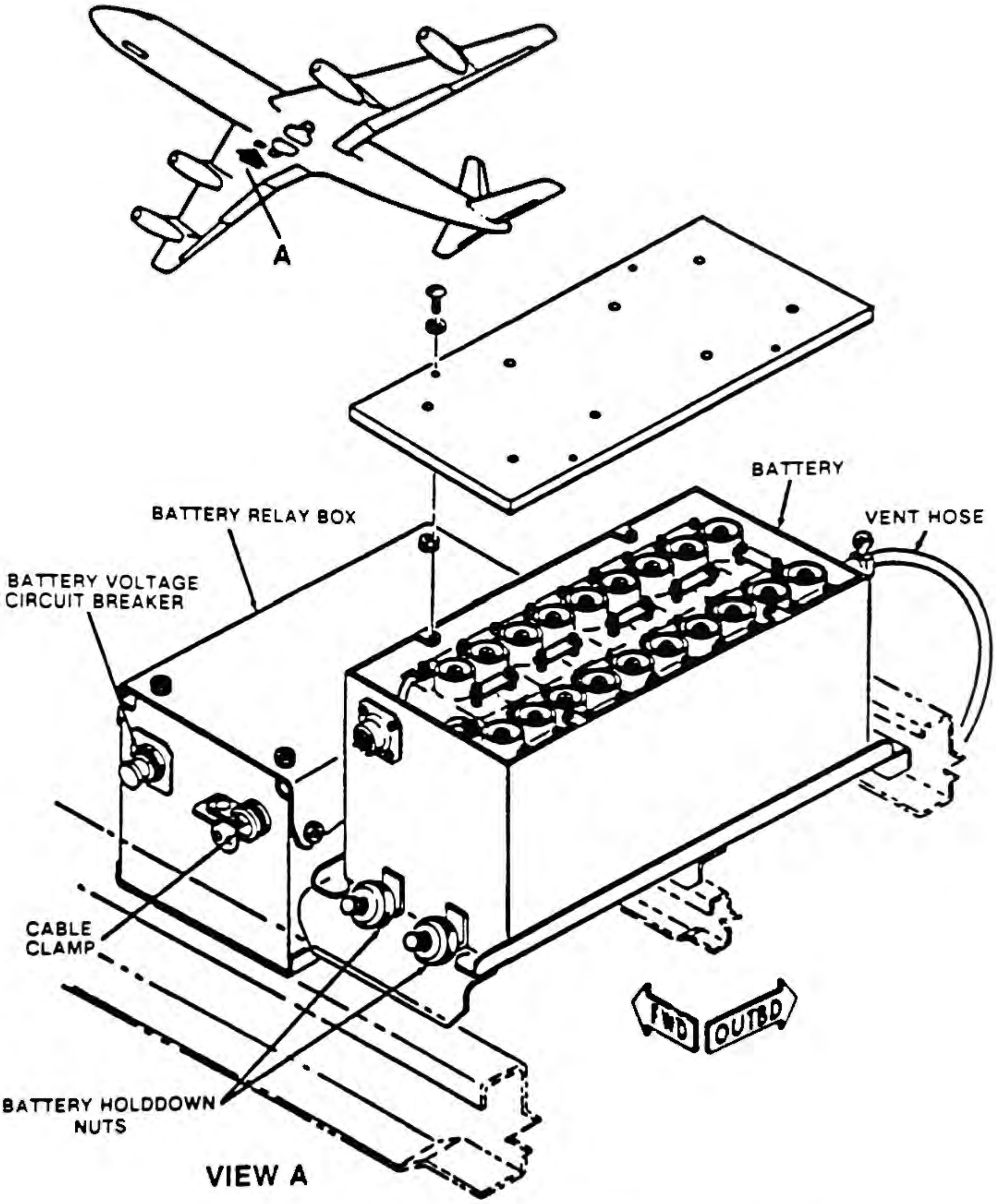
(b) The electrolyte in a nickel-cadmium battery is a solution of distilled water and potassium hydroxide. The electrolyte is used only as a conductor and does not react with the plates as does the electrolyte in a lead-acid type battery. The state of battery charge



DC POWER SYSTEM

FTX80044

Figure 24-41



BATTERY INSTALLATION - SERVICING

FTX80043

Figure 24-42

cannot readily be determined by a specific gravity reading, since the electrolyte does not change appreciably. The plates within the battery are porous and absorb the electrolyte while discharging. The plates expell the electrolyte while charging.

(c) The negative plates of the battery are cadmium oxide and the positive plates are nickel oxide. During charging, all the oxygen is driven out of the plates and only cadmium remains. The oxygen dispelled from the negative plates is picked up by the positive plates to form nickel dioxide. Toward the end of the charging process, the electrolyte will gas due to electrolysis taking place in the electrolyte. A slight amount of gassing is necessary to completely charge the battery. Therefore, the battery will lose a certain amount of water.

(d) During discharge, the reverse chemical action takes place. The negative plates gradually gain back the oxygen, as the positive plates lose oxygen. Due to this interchange of oxygen, the chemical energy of the plates is converted into electrical energy and the electrolyte is absorbed by the plates. For this reason, the level of the electrolyte should be checked only when the batteries are fully charged.

CAUTION: THE SLIGHEST ACID CONTAMINATION WILL DETERIORATE THE NICKEL-CADMIUM BATTERY. WHEN SERVICING BATTERIES, MAKE CERTAIN THAT ALL BATTERY SERVICING EQUIPMENT IS ACID FREE.

(e) One characteristic of the nickel-cadmium battery is that the cells can become unbalanced. Occurrence is generally a result of operating the battery system for extended periods without total discharge cycling. It is recommended that the batteries be inspected and removed for periodical checks for reconditioning of the battery according to the manufacturer's specifications.

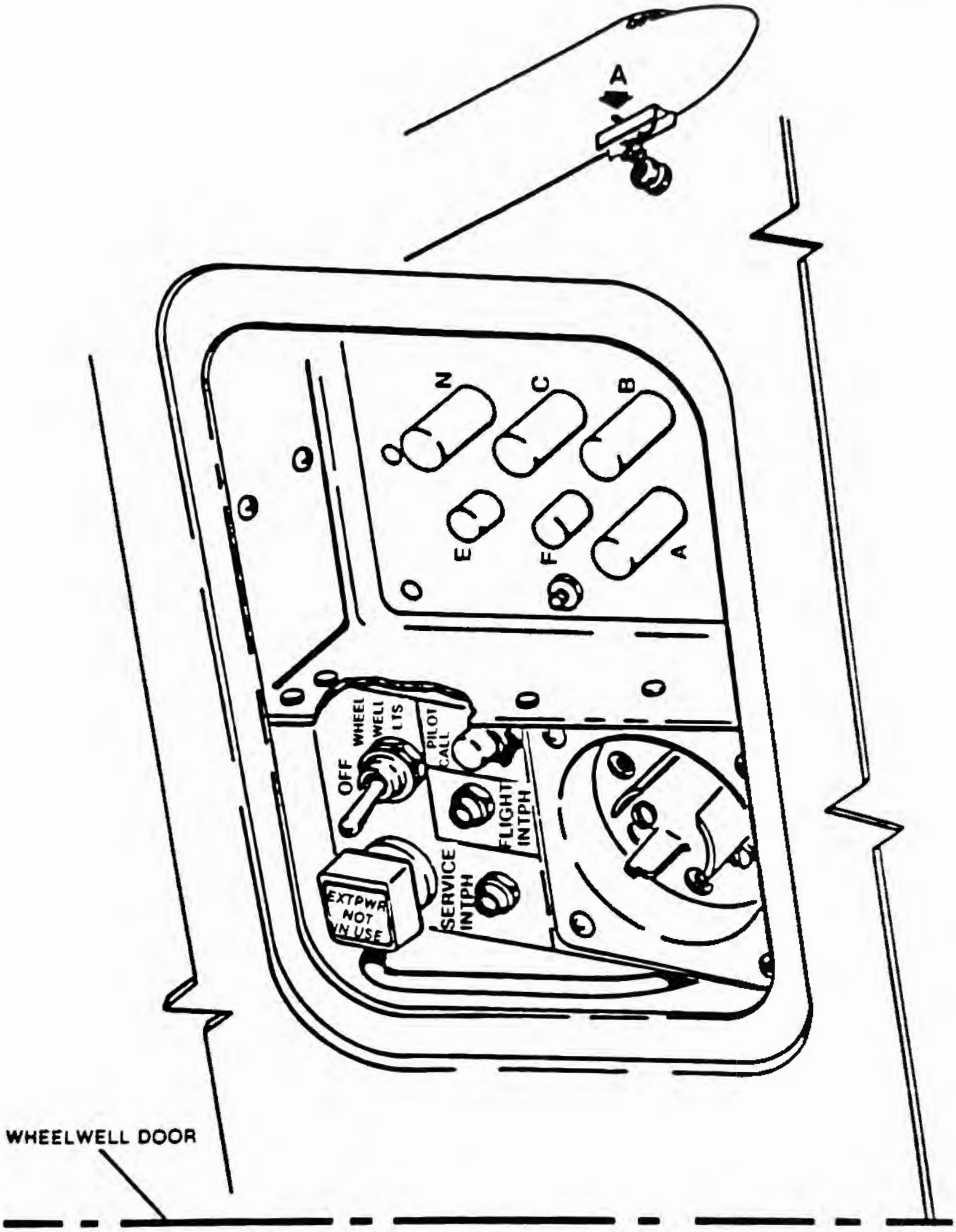
7. External Power - Description and Operation

A. General (See Figures 24-42, 24-43 and 24-44)

(1) The external electrical power system circuitry permits power to be supplied to all the AC load buses or only to No. 4 cabin bus. The circuitry consists of the external electrical power supply receptacle, bus protection panel, the No. 1 and 2 external power relays, the No. 2 external power slave relay, external power control transformer-rectifier, battery external power switch, ground service switch, external power control relay, external power not in use light, and an external power available light.

(2) When an external electrical AC power supply is connected to the external electrical power supply receptacle, two circuits are energized. The first circuit energizes the white external power not in use light, located on the external electrical power supply receptacle panel. The second circuit is the phase sequence circuit in the bus protection panel. When this circuit senses that the phase rotation of the external electrical power supply is A-B-C, the external power available light is on and power is connected from the external power control transformer-rectifier to the two external power control systems. The external power available light is a blue light located on the systems engineer's control panel. When on, this light indicates that external electrical power supply of proper phase sequence is connected to the airplane and that the load buses can be energized.

(3) When the generators are not operating, all load buses can be supplied external power by a 3-position battery-external power switch located on the systems engineer's control panel. When this switch is placed in the external power position, the No. 1 external power relay will energize, if the phase sequence relay is energized. The external power source is then connected to the AC tie bus assembly. Because the AC tie bus is connected to the load buses through the closed bus tie relays, the external power is supplied to all the electrical loads on the airplane. Operation of the battery-external power switch also turns off the external power not in use light. If the battery-external power switch is in the off position and the ground service switch, located on a switch panel near the forward passenger entrance door, is placed in the on position; power is supplied only to No. 4 cabin bus. Placing the battery-external power switch in the external power position deenergizes the ground service switch circuit. When the ground service

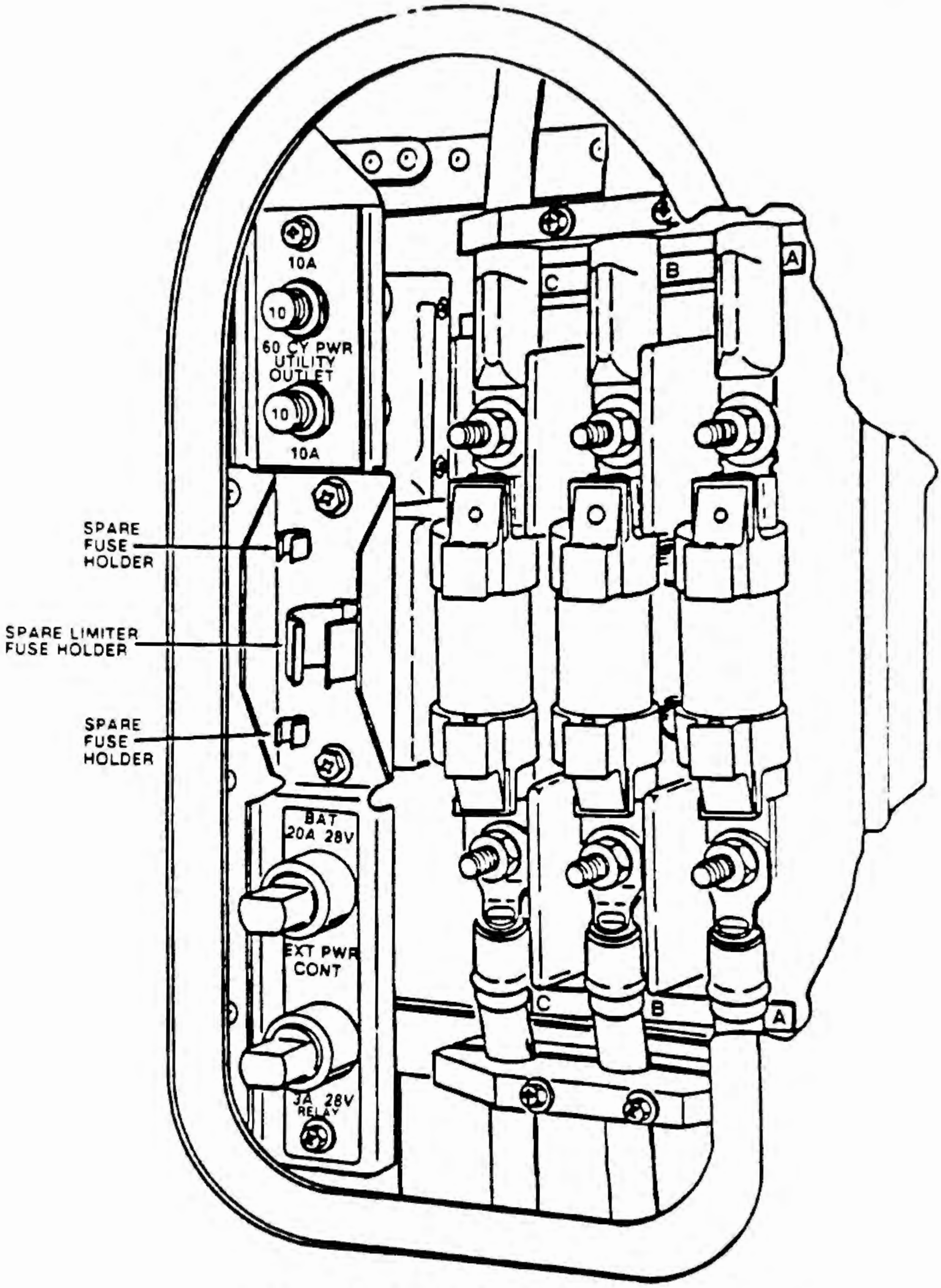


VIEW A

EXTERNAL POWER RECEPTACLE PANEL

FTX80045

Figure 24-43



EXTERNAL POWER PROTECTION PANEL

Figure 24-44

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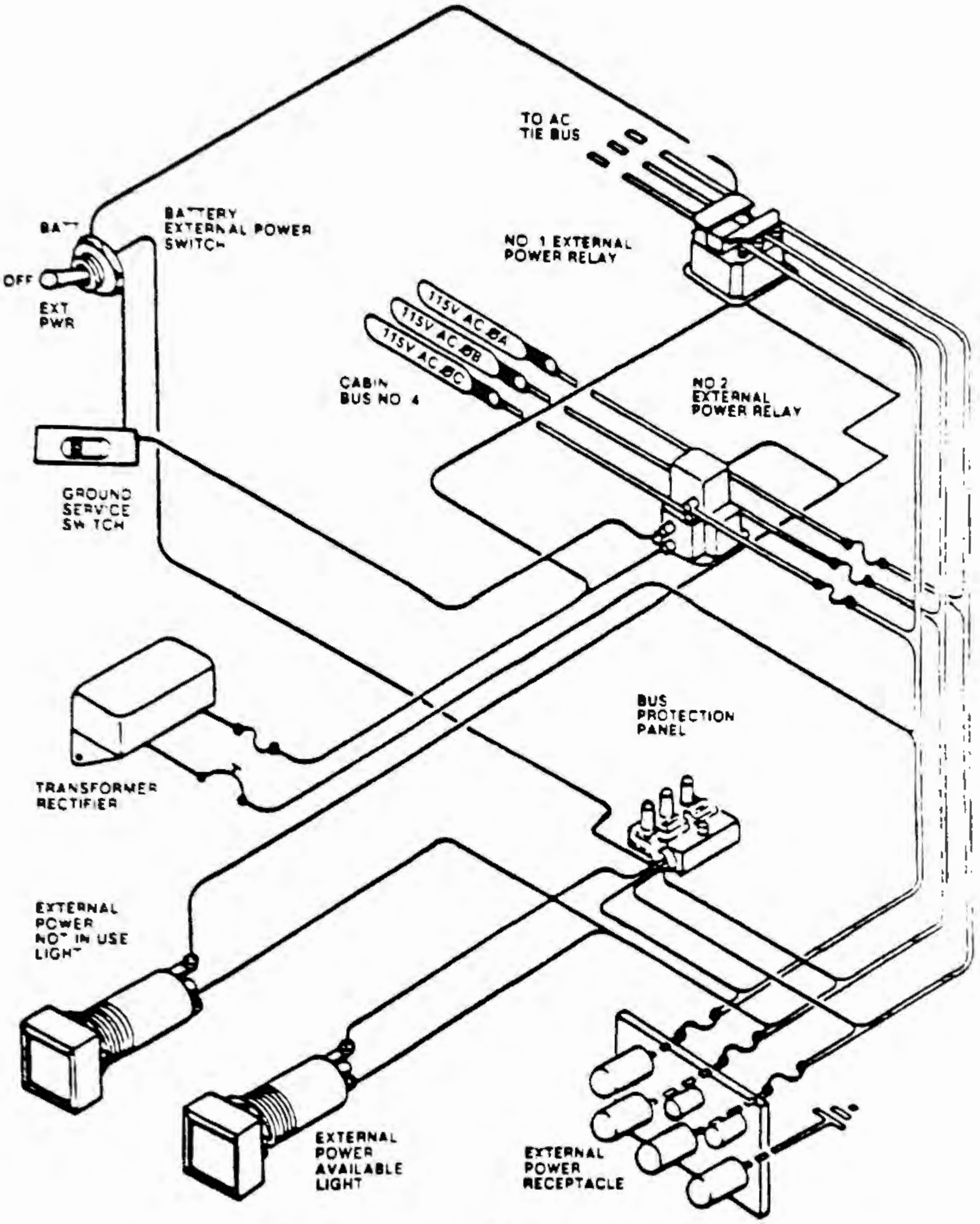

BATT
OFF
EXT PWR
BATTERY EXTERNAL POWER SWITCH
TO AC TIE BUS
NO 1 EXTERNAL POWER RELAY
115V AC ØA
115V AC ØB
115V AC ØC
CABIN BUS NO 4
NO 2 EXTERNAL POWER RELAY
GROUND SERVICE SWITCH
TRANSFORMER RECTIFIER
BUS PROTECTION PANEL
EXTERNAL POWER NOT IN USE LIGHT
EXTERNAL POWER AVAILABLE LIGHT
EXTERNAL POWER RECEPTACLE

EXTERNAL POWER-FUNCTIONAL

FTX80047

Figure 24-45

switch is operated, the No. 2 external power relay is energized and connects the external power supply directly to No. 4 cabin bus, which supplied the circuitry used for towing and ground servicing operations. When the No. 2 external power relay is energized and the external power not in use light is off.

B. Controls and Indications

(1) Battery-External Power Switch

(a) A 3-position battery-external power switch is located on the systems engineer's control panel. When the switch is in the off position, the battery is disconnected from the battery bus and no external power is supplied to the AC tie bus. When the switch is in the battery position, the airplane battery is connected to the battery bus. Placing the switch in the external power position connects the external electrical power supply to the AC tie bus.

NOTE: **When using AC external power, the battery-external power switch should not be placed in the external power position unless an external electrical power supply with a rating of 80 kva or greater is connected to the airplane.**

(b) If external electrical power is used during engine starting, the switch should be in the external power position. If the engines are to be started with no external power available, the switch must be in the battery position.

(c) If AC external electrical power is connected to the airplane prior to shutdown and the battery-external power switch is placed in the external power position, the load carried by each generator is transferred to the external power unit as the corresponding engine is shut down. The generators on the remaining operating engines continue to carry their load until the corresponding engines are shut down, at which time their load is transferred to the external power unit.

CAUTION: **IF NO AC EXTERNAL ELECTRICAL POWER IS BEING SUPPLIED TO AIRPLANE DURING ENGINE STARTUP OR SHUTDOWN, GENERATOR ON FIRST ENGINE TO BE STARTED OR LAST ENGINE TO BE SHUT DOWN TAKES TOTAL AIRPLANE ELECTRICAL LOAD. THIS CAN OVERLOAD GENERATOR AND CAUSE DAMAGE TO GENERATOR UNLESS LOAD IS REDUCED.**

(d) When the generator system is in operation, and no AC external electrical power is being used on the airplane, the switch must be in the battery position. When the airplane is left unattended, the switch should be in the off position.

(2) Ground Service Switch

(a) A ground service switch is located on a switch panel near the forward passenger entrance door. When the switch is placed in the on position, power is supplied only to No. 4 cabin bus provided the battery-external power switch is in the off position, an external electrical power supply with the correct phase sequence is connected to the airplane, and the external power available light is on. No. 4 cabin bus supplies power to the loads required for ground servicing and towing. External electrical power is not supplied to any other loads when the No. 4 cabin bus is supplied power.

(3) External Power Available Indicating Light

(a) A blue press-to-test nondimmable external power available indicating light is located on the systems engineer's control panel. The light should be on when AC external electrical power in the proper phase sequence is connected to the airplane external electrical power supply receptacle. When an external electrical power supply is connected and the light goes off, but comes on when pressed-to-test, the external electrical power supply is not of the proper phase sequence.

(4) External Power Not in Use Indicating Light

A white press-to-test nondimmable external power not in use indicating light is located on the external electrical power receptacle panel on the right side of the fuselage nose section. When an AC external power supply is connected to the airplane but is not supplying power to the buses, the light comes on. When an AC external power supply is connected to the airplane and is supplying power to the buses, the light is off. The external power plug should not be removed when the light is off unless the external power supply has been shut off.

C. Operation

(1) Battery and External Power Circuit

(a) There are two methods by which external AC power can be applied to the airplane. The first system is controlled by the battery-external power switch on the systems engineer's control panel. When the battery-external power switch is placed in the external power position with external electrical power applied, all the load buses in the airplane are supplied from the external electrical power supply. The second system is controlled by the battery-external power switch and the ground service switch located near the forward passenger entrance door. Placing the ground service switch in the on position supplied power to the No. 4 cabin bus only, providing the battery-external power switch is in the off position. No. 4 cabin bus supplies the loads necessary for ground servicing and towing.

(b) The external electrical power supply receptacle panel is located behind an access door on the right side of the airplane above the nosewheel well door. This panel contains the external electrical power supply receptacle, the 60-cycle, 115-vac external power receptacle, the external power not in use light, pilot to mechanic call pushbutton, and a jack for the service interphone system. Above the external power receptacle panel is the external power protection panel which contains two circuit breakers for the 60-cycle, 115-vac utility outlets, three limiter fuses for the three phases of the AC power system, a fuse for 28-vdc control voltage, and a fuse for ground battery voltage. The phase sequence (PS) in the bus protection panel is connected in the circuit immediately after the limiter fuses. The PS checks the phase sequence of the external electrical AC power supply and does not close unless the phase sequence is in the proper phase rotation order: A-B-C.

(c) Two of the PS contacts in parallel complete a ground for the external power available light on the systems engineer's control panel. Two other contacts are used in parallel to complete the power side of the circuit for control of the external power relays from the external electrical power control transformer-rectifier.

(d) The external power control transformer-rectifier (TR) receives power from phase A through a 3-ampere circuit breaker. The 28-vdc power output from the TR is applied to pin F of the external electrical power supply receptacle. When external power is connected to the airplane, power is applied from pin F to pin E through a jumper in the external electrical power supply plug. From pin E, a circuit is completed through a 5-ampere fuse, two contacts of the phase sequence, to normally closed contacts in the generator relay and bus tie relay in parallel for each generator. This pair of contacts for each generator is connected in series to form an interlock circuit in shutdown. The other side of the interlock circuit connects to the coils of both No. 1 and 2 external power relays. In parallel with the interlock circuit, through a normally closed contact of the No. 1 external power relay, is the coil of the bus isolation relay. The other side of the bus isolation relay coil completes the circuit through the contacts of the battery-external switch. This circuit operates when power is connected to the external electrical power receptacle, the phase sequence is operating, and the battery-external power switch is placed in the external power position. At this time, the bus isolation relay energizes, completing the trip circuit to the coil of each bus tie relay providing the corresponding generator relay is closed. If the generator relay is not closed, the corresponding bus tie relay is not tripped.

(e) When the battery-external power switch is placed in the external power position, circuit is completed through the interlock circuitry, No. 1 external power relay is energized, and external AC power is connected to the AC tie bus.

(f) With the AC tie bus now energized, the dead bus relay is energized, and the preferential circuit opens to prevent any one of the generators from being connected to the tie bus while external power is connected to the tie bus.

(g) When the battery-external power switch is placed in the external power position, the ground circuit for the external power not in use light is opened and the light goes off, indicating that the external electrical power supply is in use and should not be disconnected. When the battery-external power switch is placed in the off or battery position, the No. 1 external power relay coil is deenergized and the external electrical power supply receptacle is disconnected from the AC tie bus. At the same time, a ground is provided for the external power not in use light. The light comes on, indicating that the external electrical power supply is not being used, and the external electrical power supply plug can be disconnected.

CAUTION: **AN ARC BETWEEN EXTERNAL ELECTRICAL POWER SUPPLY PLUG AND FUSELAGE CAN OCCUR IF ELECTRICAL POWER SUPPLY IS DISCONNECTED BEFORE EXTERNAL POWER NOT IN USE LIGHT COMES ON.**

(h) When only ground servicing is required, the battery-external power switch must be left in the off position and the ground service switch placed in the on position. The No. 2 external power relay coil receives power through the same generator relay and bus tie relay interlocks, used for No. 1 external power relay, and through the normally closed contact of the No. 4 cabin bus load monitoring relay located between the coil and the ground service switch. Therefore, No. 2 external power relay cannot be energized when No. 4 cabin bus load monitoring relay is energized. Closing the ground service switch provides a return for the coil of No. 2 external power relay, through the normally closed contacts of the No. 4 cabin bus load monitoring relay and the battery-external power switch, to the ungrounded neutral of the external power control transformer-rectifier. The No. 2 external power relay energizes and connects the external electrical power supply to the auxiliary hydraulic pump power circuit and to No. 4 cabin bus only. One contact of the No. 2 external power relay completes the circuit to energize the No. 2 external power slave relay. Another normally closed contact opens the circuit for the external power not in use light, which goes off. A normally closed contact also opens to interrupt the ground return of the No. 4 cabin bus load monitoring relay so that it cannot be energized with No. 2 external power relay closed. Power is now available to the auxiliary hydraulic pump, navigation lights, air and hydraulic brake pressure indicating systems, and radio and interior lights for ground servicing and towing.

(i) Placing the battery-external power switch in the battery position energizes the battery relay and connects the battery to the battery bus.

(j) The external power control relay is energized only when 28-vdc power is applied to pin E and supplies ground to pin N of the external electrical power supply receptacle. Energizing the external power control relay transfers the No. 2 external power relay, No. 1 external power relay, and the bus isolation relay return circuit, from the external power control transformer-rectifier, to ground. The relays continue to operate in the same manner as before except that the 28-vdc external power source now supplies the control power in place of the external power control transformer-rectifier.

(2) 60-Cycle, 115-Vac Utility Outlets

(a) There is one 60-cycle, 115-vac utility outlet, which is located at the systems engineer's station. The outlet are used to supply 60-cycle, 115-vac power required for ground maintenance operations.

(b) A 3-pin, twist-lock, external power supply receptacle, located on the external electrical power supply receptacle panel, is used to supply 60-cycle, 115-vac external electrical power to the four outlets through two 10-ampere circuit breakers. The 60-cycle power circuit is entirely separate from the 400-cycle AC external electrical power supply system.

D. To Operate System (See Figures 24-45 and 24-46)

CAUTION: IF ALL LOAD BUSES ARE TO BE ENERGIZED, USE AN EXTERNAL ELECTRICAL POWER SUPPLY UNIT CAPABLE OF SUPPLYING NECESSARY AIRPLANE POWER REQUIREMENTS, 80 KVA OR MORE, WITHOUT OVERLOADING POWER UNIT. IF ALL LOAD BUSES ARE NOT BE BE ENERGIZED, POWER UNIT OF CORRESPONDING LOWER CAPACITY CAN BE USED.

CAUTION: DAMAGE TO AIRPLANE ELECTRICAL EQUIPMENT IS POSSIBLE IF AC ELECTRICAL SYSTEMS HAVE BEEN SUBJECTED TO VOLTAGES HIGHER THAN 130 VOLTS, PHASE-TO-NEUTRAL OR 225 VOLTS, PHASE-TO-PHASE DUE TO MISADJUSTMENT OF EXTERNAL POWER SUPPLY. ANY AC OVERVOLTAGE APPLIED TO TRANSFORMER-RECTIFIERS WILL RESULT IN DC OVERVOLTAGE BEING APPLIED TO DC EQUIPMENT. ALL ELECTRICAL, NAVIGATIONAL, RADIO, AND RADAR EQUIPMENT SUBJECTED TO DAMAGING OVERVOLTAGES SHOULD BE INSPECTED AND FUNCTIONALLY CHECKED ACCORDING TO APPLICABLE MAINTENANCE PRACTICES.

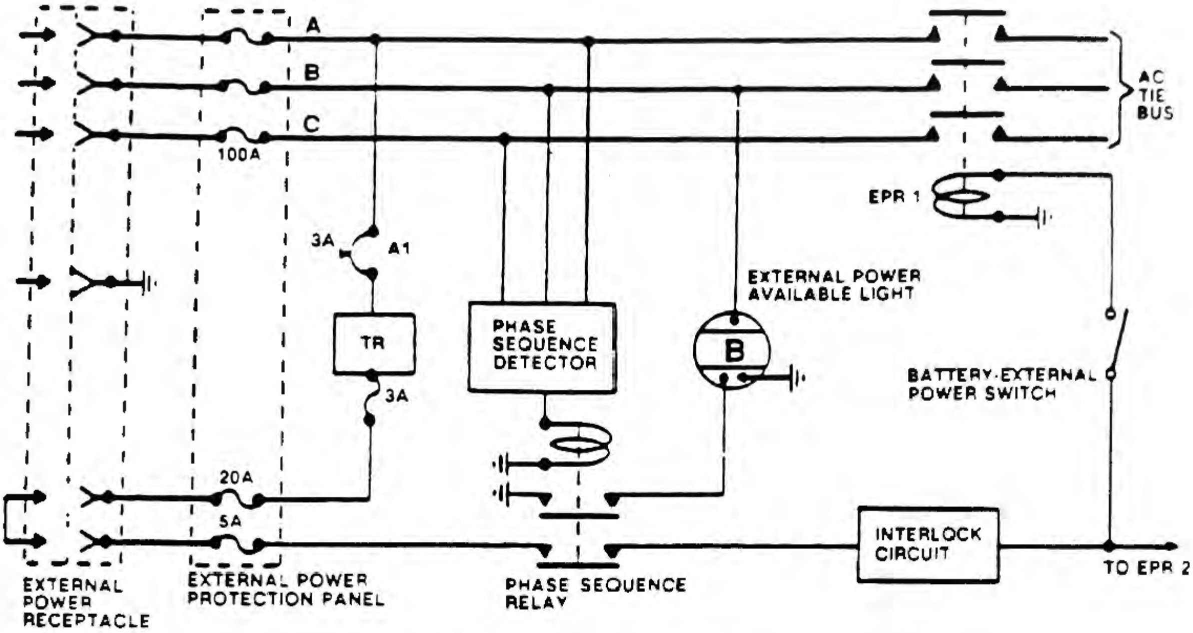
NOTE: The master warning light may come on at various points in the procedures. The light should be reset immediately before proceeding with the next step of the procedure.

NOTE: Light operation, as stated in the following procedural steps, is given only if a particular light operation is changed due to the respositioning of a switch.

(1) Energize All Load Buses from External Power

(a) Place battery-external power switch, located on systems engineer's control panel, in off position.

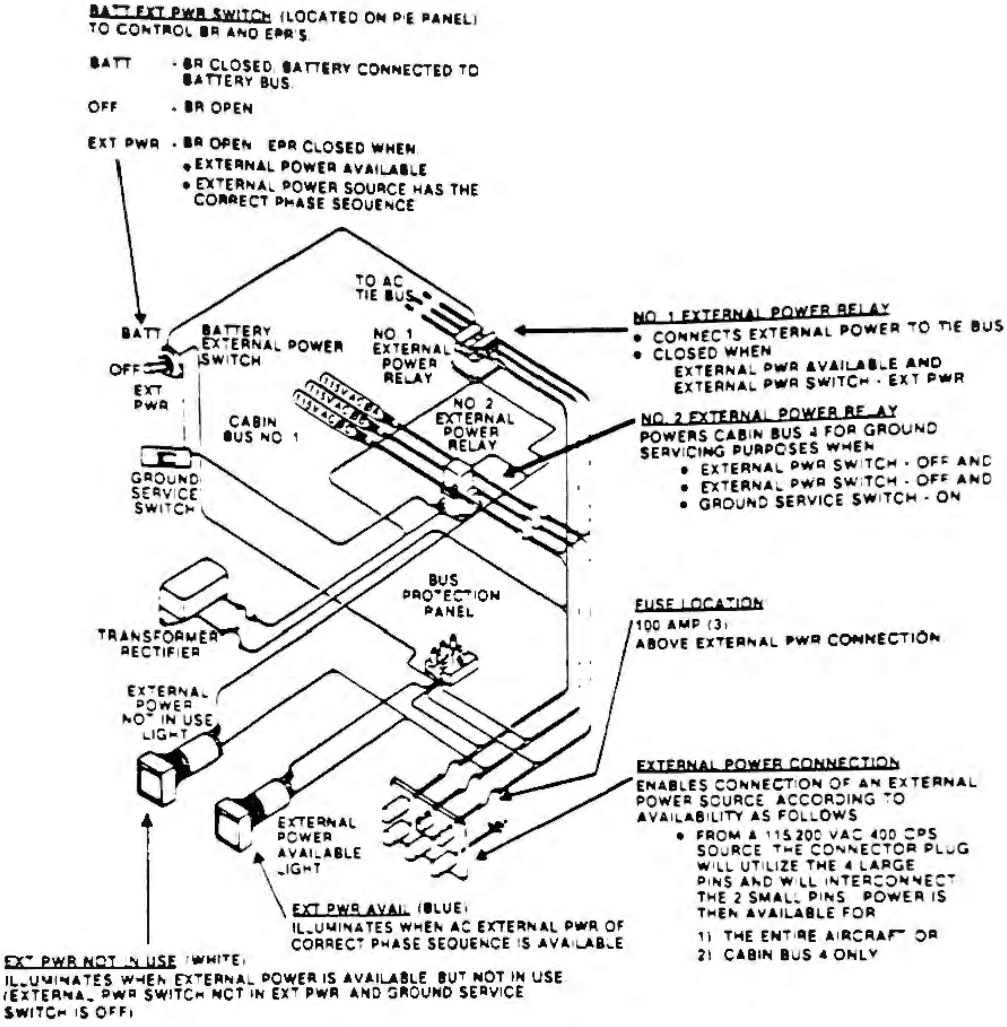
(b) Place ground service switch, located near forward, left-hand entrance door, in off position.


A
B
C
100A
3A
A1
TR
3A
20A
5A
PHASE SEQUENCE DETECTOR
EXTERNAL POWER AVAILABLE LIGHT
B
EPR 1
AC TIE BUS
BATTERY-EXTERNAL POWER SWITCH
INTERLOCK CIRCUIT
TO EPR 2
EXTERNAL POWER RECEPTACLE
EXTERNAL POWER PROTECTION PANEL
PHASE SEQUENCE RELAY

EXTERNAL POWER CONTROL CIRCUIT-SCHEMATIC

FTX80048

Figure 24-46


TO AC TIE BUS
BATT
OFF
EXT PWR
BATTERY EXTERNAL POWER SWITCH
NO. 1 EXTERNAL POWER RELAY
115VAC ØA
115VAC ØB
115VAC ØC
CABIN BUS NO. 1
NO. 2 EXTERNAL POWER RELAY
GROUND SERVICE SWITCH
BUS PROTECTION PANEL
TRANSFORMER RECTIFIER
EXTERNAL POWER NOT IN USE LIGHT
EXTERNAL POWER AVAILABLE LIGHT

BATT EXT PWR SWITCH (LOCATED ON P/E PANEL) TO CONTROL BR AND EPR'S.

BATT - BR CLOSED, BATTERY CONNECTED TO BATTERY BUS.

OFF - BR OPEN

EXT PWR - BR OPEN. EPR CLOSED WHEN:
- EXTERNAL POWER AVAILABLE
- EXTERNAL POWER SOURCE HAS THE CORRECT PHASE SEQUENCE

NO. 1 EXTERNAL POWER RELAY
- CONNECTS EXTERNAL POWER TO TIE BUS
- CLOSED WHEN
  EXTERNAL PWR AVAILABLE AND
  EXTERNAL PWR SWITCH - EXT PWR

NO. 2 EXTERNAL POWER RELAY
POWERS CABIN BUS 4 FOR GROUND SERVICING PURPOSES WHEN
- EXTERNAL PWR SWITCH - OFF AND
- EXTERNAL PWR SWITCH - OFF AND
- GROUND SERVICE SWITCH - ON

FUSE LOCATION
100 AMP (3)
ABOVE EXTERNAL PWR CONNECTION.

EXTERNAL POWER CONNECTION
ENABLES CONNECTION OF AN EXTERNAL POWER SOURCE, ACCORDING TO AVAILABILITY AS FOLLOWS
- FROM A 115/200 VAC 400 CPS SOURCE, THE CONNECTOR PLUG WILL UTILIZE THE 4 LARGE PINS AND WILL INTERCONNECT THE 2 SMALL PINS. POWER IS THEN AVAILABLE FOR
  1) THE ENTIRE AIRCRAFT OR
  2) CABIN BUS 4 ONLY

EXT PWR AVAIL (BLUE)
ILLUMINATES WHEN AC EXTERNAL PWR OF CORRECT PHASE SEQUENCE IS AVAILABLE

EXT PWR NOT IN USE (WHITE)
ILLUMINATES WHEN EXTERNAL POWER IS AVAILABLE, BUT NOT IN USE (EXTERNAL PWR SWITCH NOT IN EXT PWR AND GROUND SERVICE SWITCH IS OFF)

EXTERNAL POWER-FUNCTIONAL

FTX80049

Figure 24-47

(b) Connect AC external electrical power to airplane.

(c) Start external electrical power supply unit. Check for voltage of 115 (± 3) and frequency of 400 (± 4) cps.

(d) External power not in use light, located on external power supply receptacle panel, and external power available light, located on systems engineer's panel, should come on.

(e) Place ground service switch in on position to energize No. 4 cabin bus only.

(f) To energize all airplane load buses, perform following steps:

1 Make certain that AC bus isolation switch is in normal guarded position.

2 Make certain that DC bus isolation switch is in normal guarded position.

3 Make certain that emergency electrical control switches are in bus power normal position.

4 Place battery-external power switch momentarily in battery position and then to external power position. External power available and external power not in use indicating lights should go off.

(2) Disconnect AC External Electrical Power

(a) Place battery-external power switch in off position. External power available and external power not in use lights should be on.

(b) Place ground service switch in off position.

(c) Check that external power not in use light is on.

(d) Place external power supply unit master switch in off position.

(e) Shut off external electrical power supply unit.

(f) Disconnect external electrical power supply receptacle from airplane.

CAUTION: DO NOT DISCONNECT EXTERNAL ELECTRICAL POWER SUPPLY RECEPTACLE WHILE SUPPLY UNIT IS OPERATING AND SUPPLYING POWER.

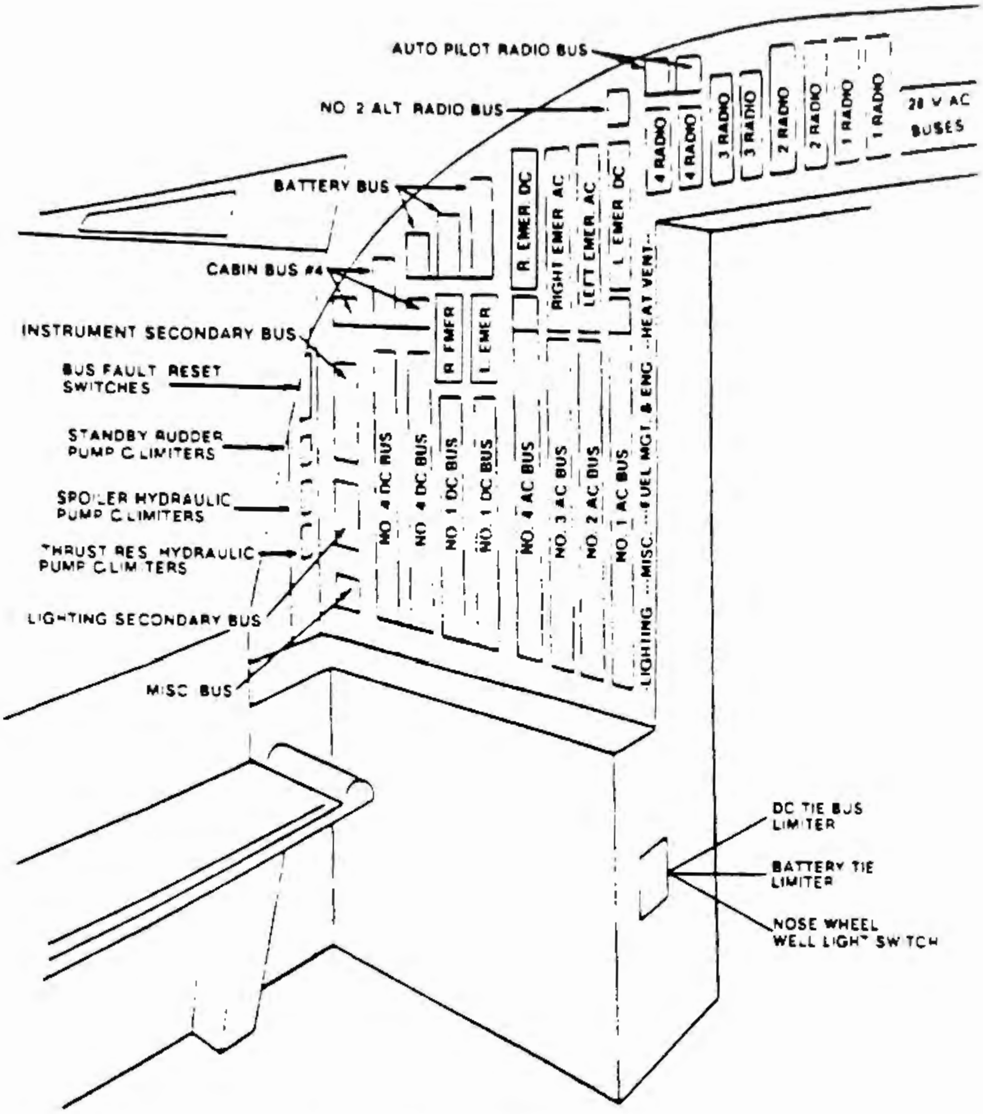
E. General (See Figures 24-47 and 24-48)

(1) Electrical load distribution, from the power sources to the various airplane loads, is accomplished by generator relays, bus tie relays, load monitoring relays, generator buses, AC and DC emergency buses, and the AC and DC tie buses. The electrical power center (EPC) provides a central location for electrical power distribution. The buses and circuit breakers used in the electrical system are located in the EPC.

(2) Each of the four generator buses consists of 3-phase heavy power leads that connect a generator relay to a corresponding bus tie relay and load monitoring relay. A set of feeder leads connects a generator relay to the bus tie relay and supplies power to respective current transformer and limiter fuse box. The current transformer supplies induced generator bus current to the corresponding load monitoring relay that controls the AC generator.

(3) The four generator buses are interconnected to the AC tie bus through corresponding bus tie relays. External power is connected to the AC tie bus through the No. 1 external power relay. The AC tie bus is located in the EPC generator bus bay.

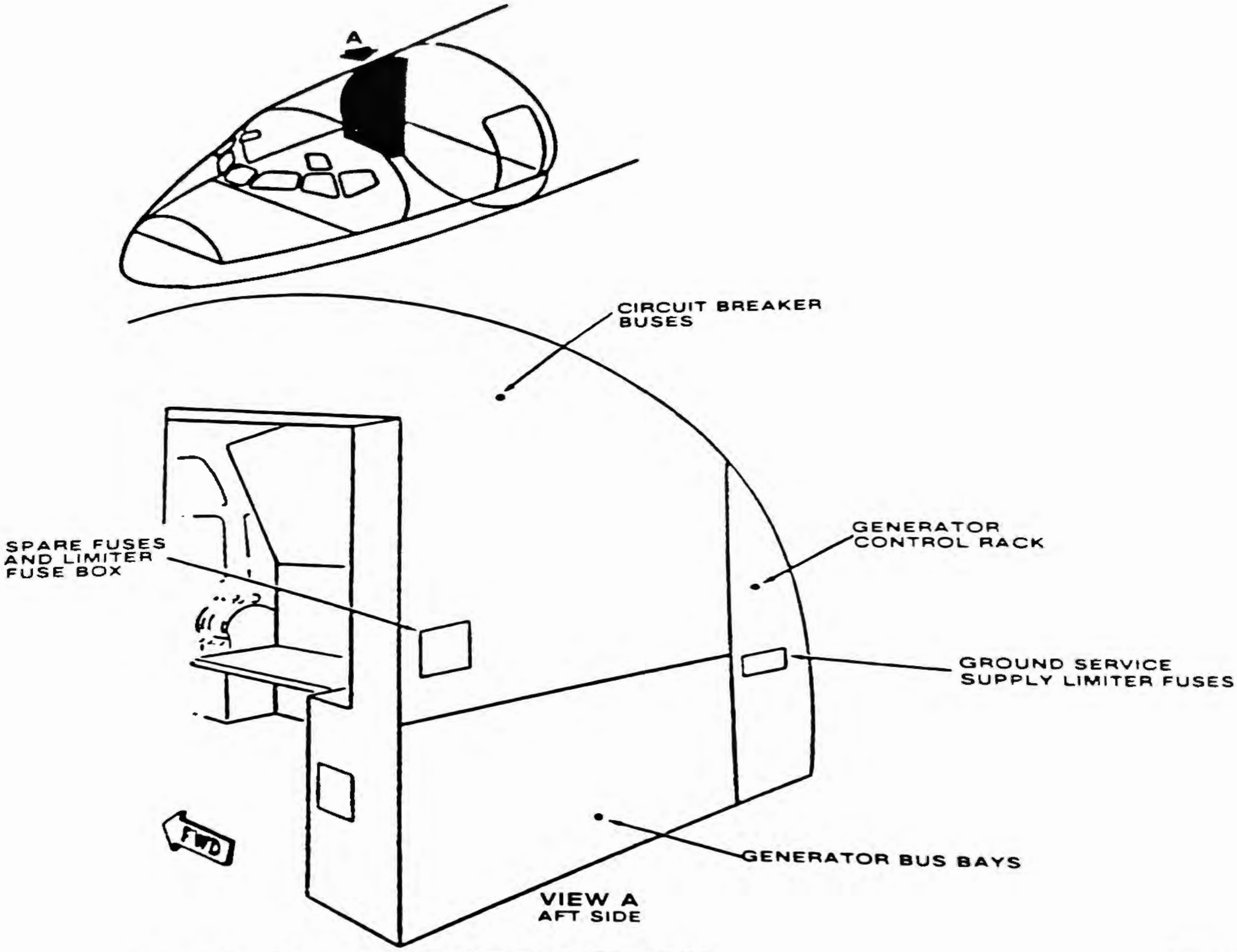
(4) The DC tie bus is located in the EPC aft equipment panel. No. 1 transformer-rectifier is connected directly to the DC tie bus through a DC limiter fuse. No. 2, 3, and 4 transformer-rectifiers are connected to the DC tie bus through corresponding DC limiter fuses and an isolation relay. During normal operation, the four transformer-rectifiers are connected to the DC tie bus and supply 28 volt, DC power to the respective DC load buses through corresponding load monitoring relays. In addition, the No. 2 and 3 transformer-rectifiers supply power to the left and right DC emergency buses, respectively.



ELECTRICAL POWER CENTER

FTX80050

Figure 24-48



ELECTRICAL POWER CENTER
Figure 24-49

FTX80051

(4) Circuit breakers fed by a common power source are connected with a flagged bus assembly. A feeder cable connects the power source to the bus. The lug spacing on the bus assembly is predetermined to coincide with individual circuit breaker locations.

8. A.C. System Trouble Shooting

A. General (See Figure 24-49)

(1) Localizing trouble in the DC-8 A.C. system is difficult because many of the operations are automatic in nature and only the final results are evident. Some assistance in isolating frequency problems to the CSD or frequency and load controller is provided on airplanes having the fine frequency test switches. (DC-8-61).

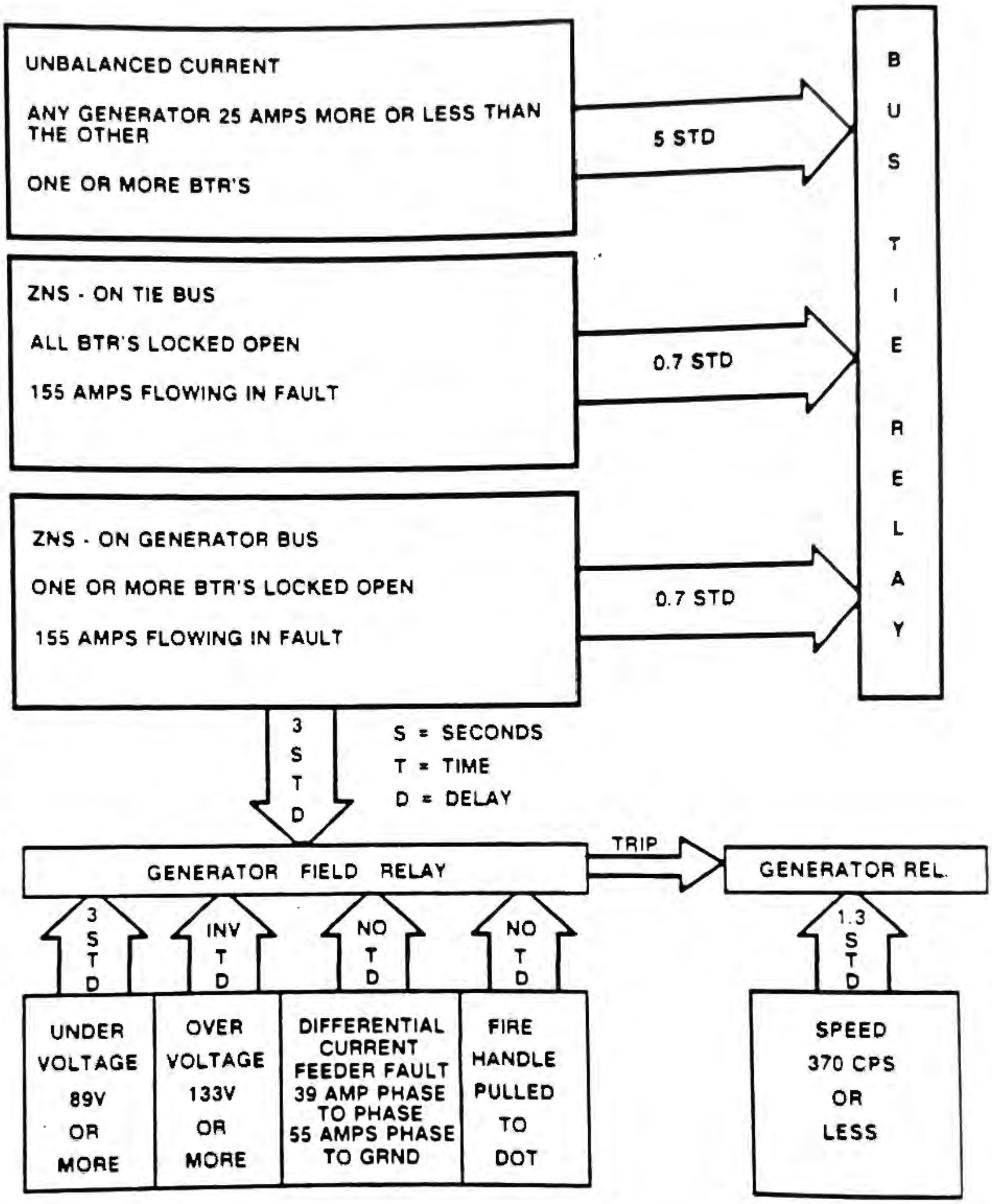
(2) Data from shop reports, line stations feedback, and log reports have been analyzed and the following information has been developed to assist those maintaining the system. More attention should be paid to the review of the flight log sheets for the past 25 hours to determine if the malfunction has been corrected. If, for example, a generator control panel has been replaced by maintenance there is little likelihood that another control panel change will correct the problem. Without an engine run, and/or specific information it is most difficult to correct a malfunction with the change of a "Black Box".

B. Common Faults (BTR trip)

There are only two faults that will trip a BTR. Namely, unbalance current or a ZNSR fault. Therefore, any time a BTR opens, either a ZNSR or unbalance fault has occurred.

(1) ZNSR Fault

Generally, a ZNSR fault will trip the BTR almost immediately. If the ZNSR fault still continues after a period of two to four seconds, that system Generator Relay and Generator Field Relay will also trip. ZNSR sensing is taken off between the generator and the input side of the GR. Therefore, whenever a generator unparalleled light comes "ON" and it is established that the BTR tripped and not the GR, the trip was due to unbalance current only. How to establish whether a GR or BTR tripped whenever the generator unparalleled light comes "ON" and the voltage and frequency are normal will be discussed


UNBALANCED CURRENT
ANY GENERATOR 25 AMPS MORE OR LESS THAN THE OTHER
ONE OR MORE BTR'S
5 STD
ZNS - ON TIE BUS
ALL BTR'S LOCKED OPEN
155 AMPS FLOWING IN FAULT
0.7 STD
ZNS - ON GENERATOR BUS
ONE OR MORE BTR'S LOCKED OPEN
155 AMPS FLOWING IN FAULT
0.7 STD
BUS TIE RELAY
3 STD
S = SECONDS
T = TIME
D = DELAY
GENERATOR FIELD RELAY
TRIP
GENERATOR REL.
3 STD
INV TD
NO TD
NO TD
1.3 STD
UNDER VOLTAGE 89V OR MORE
OVER VOLTAGE 133V OR MORE
DIFFERENTIAL CURRENT FEEDER FAULT 39 AMP PHASE TO PHASE 55 AMPS PHASE TO GRND
FIRE HANDLE PULLED TO DOT
SPEED 370 CPS OR LESS

GENERATOR FAULT DETECTION

FTX80053

Figure 24-50

further in this write-up. However, if both a BTR and GR trips, Bus Power Failure Light "ON" and it is not possible to "reset" the BTR through the "bus fault reset switch" then either a ZNSR signal was sent to the generator control panel or the control panel malfunctioned. The substitution of a control panel known to be in good operating condition will point out the area in which the problem exists. If the replacement panel does not correct the trouble then the three input sensing leads from the GR relay should be checked for opens or shorts. If this is normal, then proceed directly to the generator. Check power leads for security, continuity, and leakage to ground between generator and point of attachment to BTR (also contact points in the GR): Do not overlook an actual open or shorted phase in the generator itself. Voltage regulator, frequency and load control units, defective C.S.D.'s mag trim heads etc., will not correct the problem here.

(2) Unbalanced Current

(a) Whenever a generator unparalleled carries its own load and it has been established that the BTR tripped because of unbalanced current, there is an entirely different problem area. The greatest percentage of BTR trips are due to unbalanced current.

(b) Unbalanced current may be caused by a generator accepting current, acting like a motor, or hogging real load because its frequency is too high. If its voltage and frequency is higher than the A.C. tie, it will hog reactive and Real load correspondingly. If its frequency and voltage is down, it will shed load with respect to the other generators. That is, the other generators through the A.C. tie will feed that generator real or reactive load thus causing unbalanced current trip. It is important to observe the frequency and voltage of a generator any time it is operating unparalleled and carrying its own load. If the voltage is above or below the A.C. tie voltage, we have a field excitation problem. This is completely independent of frequency. It is important to remember that frequency and voltage problems are generally in two separate areas. The devices that control these factors do so independent of each other. For voltage problems, don't look for a frequency and load controller to give any help, or malfunctioning CSD or generator control panel. There are exceptions, but not many. For frequency problems stay away from voltage regulator and generator control panels. Look for trouble at the CSD, open mag trim head, or connector trouble to the mag trim head. There have been quite a few occasions where only after several attempts to change generator control panels and frequency load controller. that it was determined that the mag trim head was open. This means that during all this trouble, the CSD was on basic governing and not able to compensate for any load change. If it were running close enough in frequency to the A.C. tie and its generator loads were not too great, it could operate this way for weeks. However, large load changes, coupled with mechanical deterioration of the CSD, will cause the frequency of that generator to vary with respect to the A.C. tie. This will then result in erratic tripping of the BTR for that system. Unbalance current? Yes! Why? Because that generator was either hogging or shedding real load. The 31, 50 and 61 series aircraft have Fine Frequency Control Test switches installed. Whenever there is a question as to whether or not the mag trim head is actually operative, unparallel the generator and position the Fine-Freq-Control switch for the generator to test. If the mag trim head is functioning, the generator should be driven down in frequency to about 392 cycles. If no change is noted then frequency problems exist in the mag trim head and/or its control system.

C. Generator Relay Trip

(1) There are only two events that will trip a GR by itself: Namely, turning the generator control switch to off or opening of the USS. Remember, under this section we are only talking about a GR trip only and not a GR trip along with its Field Relay. When this switch is once again activated, it will be very difficult, when a generator unparallels to determine whether or not the BTR or the GR opened. One method which may assist in determining if the GR or BTR tripped is the monitoring of the applicable loadmeter while turning the suspected generator "off" and "on". However, if bus loads for that generator are light, a change may be noted.

(2) If there is any doubt as to loadmeter reading, turn the generator switch for that system to "off" if the GR originally opened, whenever the generator switch for that system is turned "off" the bus power-failure light will stay out. This is because the BTR for that system is already closed. However, when the generator controls switch is turned "off" and the bus power-failure light flickers "on" for a moment then goes "out" (or stays "on" continuously) this would indicate that originally, the BTR tripped for unbalanced current and not that the

generator is "off" the line, it would once again close. Of course, if at anytime the generator unparallel light comes "on" and we find no volts or no frequency indicated for that generator. We know that a GR and Field trip occurred. The causes for this type of failure will be discussed in subsequent paragraphs. Remember, the GR will open (only by itself) if the USS opens or the generator switch is turned "off".

D. GR and Field Relay Trip

(1) The following action will trip the GR and its Field Relay only. This will be evidenced by NO volts or frequency indicated on the applicable system.

(2) To summarize, these faults will be:

(a) Overvoltage-generator unparalleled is paralleled then over- excitation.

(b) Undervoltage-generator unparalleled if paralleled then under- excitation.

(c) Differential protection.

(d) Fire shutoff lever to dot position.

(3) Overvoltage-Undervoltage

It can be seen that it becomes considerably more difficult to pin the problem area down when there is an inoperative generator with no voltage or frequency present. Run the engine and see if it is possible to pick up a clue before the system trips again. It should be understood that this technique will not work in all cases, but for those that it will work, it is worth the time and effort in trying to pin the problem down. With generator switch "off" and engine idle, actuate the AC bus isolation switch. This will open the BTR for the system under test as well as turn "on" the bus-power-failure light. If it goes out momentarily then comes back "on" the bus-power-failure light. Turn the generator switch to "reset" then "ON", watch bus-power-failure light. If it goes out momentarily then comes back "on", most likely the problem is overvoltage. If bus-power-failure light does not go "off" at all, or goes "off" for two to four seconds then comes back "on".

Then the problem most likely is undervoltage. Note that we are not talking about the type of excitation that causes parallel reactive load problems, but rather single generator excitation that causes over or under voltage problems. The generator under test is unparalleled so all Real and Reactive load sensing circuits are shorted out through the closed auxillary contacts of the BTR. Over voltage problems are generally caused by the voltage regulator. Substitution here is in order. However, if this does not correct the problem take a close look at the differential protection system. Information relative to differential protection will be found further in this write-up. The generator may also be at fault due to a partically shorted field. Continuity check through the generator field should be done. Do not overlook broken wiring or high resistance connections through receptacles, but stay with field excitation circuit only. Run engine at idle speed with voltmeter set on AC volts and a range setting of approx. 150 VAC. Check form post on generator PM 3 to PM 2 and from PM 3 to PM 1, voltage should be 105 VAC + or -1.5 Volts. If the voltage is not correct replace generator.

E. Typical Problems

(1) When a generator reparallels and still shows voltage and frequency a BTR trip occurred. The next point to establish is whether the BTR tripped because of unbalanced current or a ZNSR fault. Reparallel the generator, if it unparallels immediately, then the trip was ZNSR. If it comes off the line after two to four seconds then the trip was due to unbalanced current. Assuming it came off the line in approximately 2-4 seconds, it has now been established that an unbalanced current problem exists. Unbalanced current may result from frequency or voltage differences between that generator and the A-C tie bus. In case the voltage was 119, this is approximately 4 volts higher than the A-C tie. Whenever this generator was put on the A-C tie which is running at 115 volts, it would tend to hog the reactive load thereby causing an unbalance current trip. Voltage can be set on the voltage regulator. With this same situation assume that the BTR tripped off immediately and the voltage was 115 and the freq. was 400. This indicates there was a ZNSR trip. However, you should note that the generator for that system is still carrying its own load. The fact the generator does carry its load means that the ZNSR fault is certainly not down stream in that generator system. It has to be at the BTR, or from the BTR to the A-C tie. One open phase, broken lugs, etc. will do this, or even a bad power contact in the BTR itself.

(2) Generator unparallels-Voltage normal; frequency low. Another typical case: The generator unparallel light comes "ON", its voltage is 115 and its freq. is 397, while the A-C tie freq. is 401 cycles. Actually, the freq. of the generator is not really outside of its working tolerance, but when joined with the A.C. tie, which is operating at 401 cycles, this generator will tend to act like a motor, with the A-C tie pushing this generator. Of course, this creates unbalanced current. Frequency and load controller replacement is a good place to start. However, do not change the unit and release the aircraft without an operational check to see if the problem has been corrected.

(3) It could very well be that a wiring problem exists at the mag trim head, a high resistance connection or even broken wiring, so that the CSD is only running on basic governing. A continuity check should be made. There will be many times that a generator will unparallel while its voltage & freq. are normal. These are the difficult areas to locate. A poor electrical connection, for example, to the mag trim head will allow either the CSD to be on basic governing or Real load sensing through the trim head. Loads and the condition of the CSD, as we mentioned before, as well as the point where the mag trim heads open up due to a poor connection, can cause unbalance tripping. Loose wiring in generator power leads or connection points at generator and generator relay, or even BTR relay, can give occasional ZNSR faults. also check pins in power lead pylon connector for burned pins. In any case, avoid the changing of a black box just for the sake of doing something. There is no assurance that the black box could be anymore erratic than a loose connection somewhere in the system. Shop records regarding generator control panels and frequency and load controller would seem to confirm this fact. They have not been chronically erratic. Up to this point, we have been talking about some of the actual failures in the system and the types of presentation that should be expected. The sensing circuits are active whenever generators are parallelled to control Real and Reactive load distribution. If these sensing circuits open, short, or are cross-wired, they too, will present the same type of faults you would expect from over-excitation or under-excitation of unbalanced current problems. These loops may be checked as follows:

(a) Reactive Load Loop

To check the reactive load division loop for any one system under suspicion open the loop by first disconnecting wire X58D24 from

2NC on #4 BTR. Leave X58E24 attached. This step is applicable to any of the four generating systems. This step merely opens the loop between the four systems and leaves the loop closed for that system under test. Trip all GR's except the one under test. This can be done by turning off the applicable generator control switches. Now one generator is feeding the aircraft loads. This should be monitored so as not to exceed the capacity of that generator. Now, apply an inductive load, such as the auxiliary hydraulic pump or alternate stabilizer trim actuator. Observe the voltage on the aircraft voltmeter as the inductive load is applied. Voltage should decrease as the load comes on the system. If voltage increases, or remains the same there is an error of some kind in only that portion of the reactive loop. Perhaps bad auxiliary contacts on GR or BTR exist.

(b) Real Load Loop

To check Real load division loop, for any one system under suspicion open the loop by first disconnecting wire X73A24 from 3NC or #4 BTR. Leave X73E24 attached. This step is necessary when checking any of the generating system in order to open the loop between the four systems and leave the loop closed for the system under test. Trip all GR's except the one under test. This can be accomplished by turning "off" the applicable generator contrtol switches. Now one generator is feeding all aircraft loads. This should be monitored so as not to exceed the capacity of that generator. Apply a resistive load, such as turning on one or more boost pumps. Observe the freq. of the generator under test as load is turned on. The freq. should decrease as the load is applied. If the freqs. increase or fails to decrease, there is a wiring error or a malfunction in that system real sensing loop.

F. Differential Protection Sensing

A fault here will cause a GR and GR field trip. The fault can be in either of three areas; a malfunctioning generator control panel, a sensing wiring fault or a true short-circuit fault. A substitution of a good generator control panel will clear the fault area. If the generator field relay trips after closing the GR and adding load, an open circuit or incorrect wiring of the differential protection system is probably at fault. With the engine at idle and generator unparalleled, obtain A.C. voltmeter, check voltage at T1, T2., & T3 of generator relay. Apply a small load, (one booster pump) and see if voltage stays the same, you should have 115 volts at each phase to ground. If voltage is not the same check pylon plug for burnt pins, or wiring. If nothing found there disconnect connector from current transformer and fuse box. Using wiring diagram for the aircraft take an ohm meter reading and wring out wiring from control panel to engine. All three current transformers on engine should read the same.

G. Summation

The few points covered above will not find all trouble in this system and is not the intent. We can have compound failures of such a nature that they will nullify much of the above information. The point here is, first get into the proper area with a few simple basic checks. Then proceed to explore this area with detailed trouble shooting.

9. 61 - Differences

A. The basic electrical system operation is similar to the 62/63 series aircraft with the following exceptions. The 61 Series has a fine frequency control which maintains a frequency of 400 +/- 0.1 CPS. Also on the 61 Series the CSD oil is cooled by low pressure fuel in the fuel temp regulator.

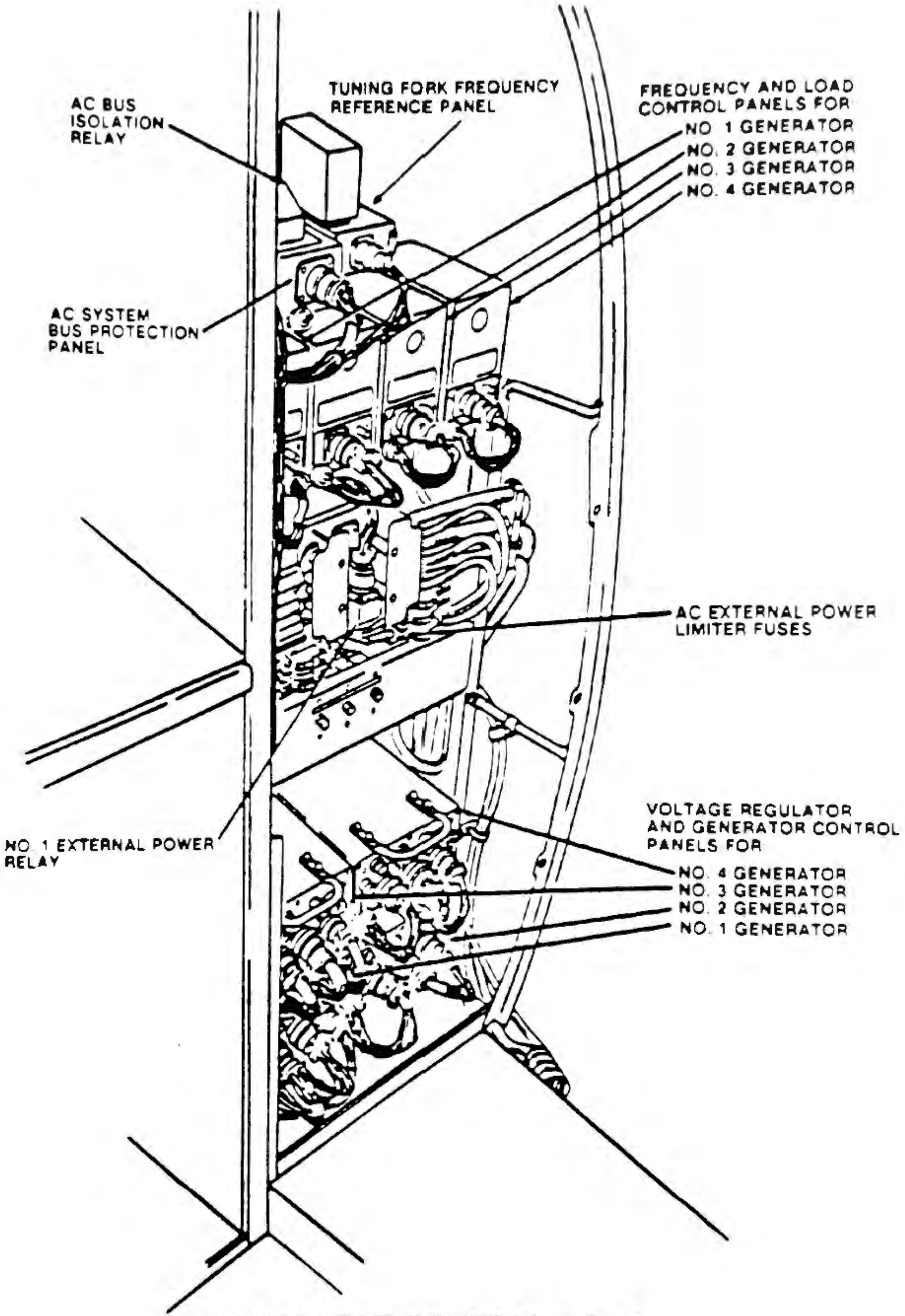
B. Tuning Fork Frequency Reference Panel (See Figure 24-50)

(1) One tuning fork frequency reference panel, located in the generator control rack, is used as a reference signal for close frequency control of the four generators.

(2) The heart of the frequency reference is a high-precision tuning fork which, when set into vibration by any random external noise, vibrates at 400 (±0.1) cps. This mechanical vibration is picked up and amplified in the tuning form assembly. The output of the frequency reference is supplied to each of the frequency and load control panels.

C. Frequency and Load Control Panels (See Figure 24-50)

(1) Four frequency and load control panels, one for each generator drive system, are located on the EPC generator control rack. The panels have two functions: To maintain a synchronous frequency and an equal electrical load distribution among the operating ac generators.


AC BUS ISOLATION RELAY
TUNING FORK FREQUENCY REFERENCE PANEL
FREQUENCY AND LOAD CONTROL PANELS FOR
NO. 1 GENERATOR
NO. 2 GENERATOR
NO. 3 GENERATOR
NO. 4 GENERATOR
AC SYSTEM BUS PROTECTION PANEL
AC EXTERNAL POWER LIMITER FUSES
VOLTAGE REGULATOR AND GENERATOR CONTROL PANELS FOR
NO. 4 GENERATOR
NO. 3 GENERATOR
NO. 2 GENERATOR
NO. 1 GENERATOR
NO. 1 EXTERNAL POWER RELAY

GENERATOR CONTROL RACK

FTX80058

Figure 24-51

(2) A static frequency comparator circuit within the panel monitors and compares the corresponding generator frequency with that of the tuning fork frequency reference signal. If a generator is off frequency, the control panel transmits a corrective signal to the corresponding signal to the corresponding CSD transmission governor magnetic trim head and CSD transmission output speed is increased or decreased accordingly.

(3) Equal load distribution is maintained by the load division circuit within the panel. The circuit monitors and compares the load on the corresponding generator with the average load of all generators operating in parallel. If a generator is assuming more or less than the average load, the control panel transmits a corrective signal to the corresponding CSD transmission magnetic trim head and the CSD output speed is increased or decreased accordingly.

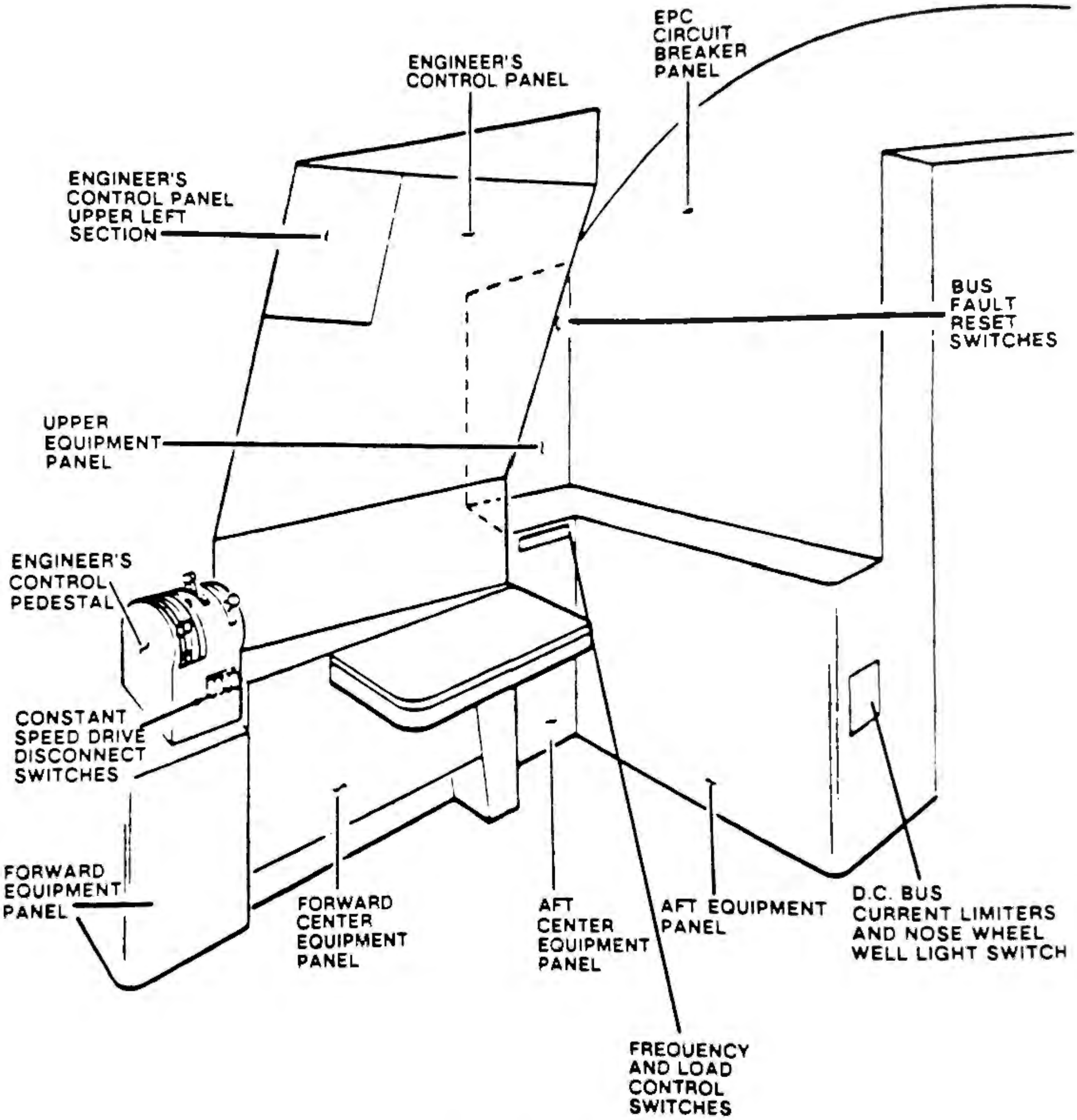
D. The CSD oil is cooled as it is pumped through a division of the engine fuel temperature regulator. Although the fuel temperature regulator serves as a common unit for the CSD oil, engine fuel and engine oil systems, each system is independent of the other and the fluids are never intermixed. As a result, one system cannot become contaminated by either of the other systems.

10. Frequency and Real Load Control (See Figures 24-51 and 24-52)

A. Frequency and Real Load Control is provided to maintain generator output frequency at 400 cycles and to provide equalization of Real Loads between paralleled generators. To provide control of frequency and real load the following components are used:

(1) The tuning fork control panel supplies a precision 400 cycle signal to each frequency and load control panel.

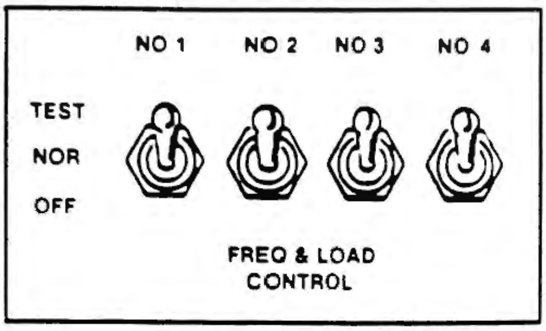
(2) The frequency and load control panel compares the reference frequency signal from the tuning fork, with generator output frequency. Any difference in these frequencies is used to control the generator drive transmission (CSD) speed governor control which regulates the frequency of the generator output. Any difference in frequencies generates a d.c. voltage which is applied to the CSD governor magnetic trim head.


EPC CIRCUIT BREAKER PANEL
ENGINEER'S CONTROL PANEL
ENGINEER'S CONTROL PANEL UPPER LEFT SECTION
BUS FAULT RESET SWITCHES
UPPER EQUIPMENT PANEL
ENGINEER'S CONTROL PEDESTAL
CONSTANT SPEED DRIVE DISCONNECT SWITCHES
FORWARD EQUIPMENT PANEL
FORWARD CENTER EQUIPMENT PANEL
AFT CENTER EQUIPMENT PANEL
AFT EQUIPMENT PANEL
D.C. BUS CURRENT LIMITERS AND NOSE WHEEL WELL LIGHT SWITCH
FREQUENCY AND LOAD CONTROL SWITCHES

E.P.C. PANEL LAYOUT

FTX80054

Figure 24-52



FTX80056

Figure 24-53

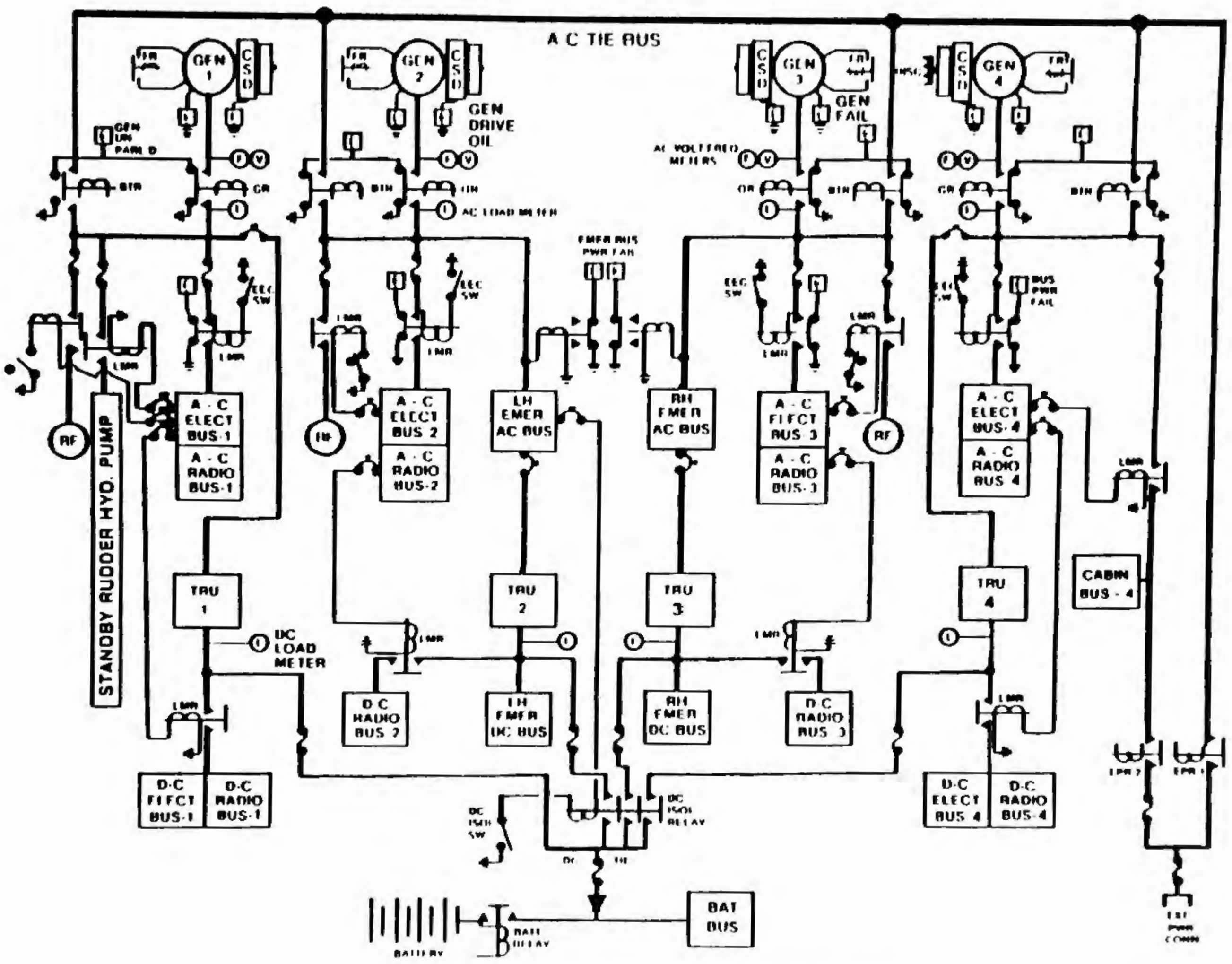
(3) The Real Load Equilization Loop corrects for any current unbalance between paralleled generators. This loop consists of four current transformers, which are located, one in each box, in the current transformer and fuse boxes. Two sets of contacts, one in the BTR and one in the GR, are in parallel with the corresponding CT. These contacts are used to short the Real-Load CT when the generators are not in parallel operation. The input circuit of the load control panel is also in parallel with the C.T.'s. Any current unbalance from the average current in the loop must flow from the C.T. to the load control panel. The output from the load control panel is a D.C. voltage proportional to the real load unbalance. Therefore any unbalance in real-load division will be used to adjust the CSD Speed Governor Control, thereby regulating the torque of the generator drive shaft.

(4) Four frequency and load control switches (one for each control panel) are installed aft of the Flight Engineer's work table on the aft center equipment panel. The switch positions are:

(a) OFF - interrupts signal from frequency and load control to CSD Governor magnetic trimhead. Generator frequency is controlled by CSD mechanical governor to 400 ± 4 CPS.

(b) NORMAL - Frequency and load control regulates generator frequency to 400 ± .1 cycles.

(c) TEST - An error signal of high frequency is induced into the Load Control Panel, which drives the generator frequency lower. When switch is released it returns to normal position, the error signal is removed, the Load Control Panel causes the generator to return to 400 cps. The test position can be used to aid in rapid paralleling of the generators.



ELECTRICAL GENERATING SYSTEM

FTX80059

Figure 24-54

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GENERATOR PARALLEL BUTTON. When depressed momentarily, this button will initiate generator paralleling (closing the BTR's) provided the battery-external power switch is in position BATT and AC bus isolation switch in position NOR.

AC BUS ISOLATION SWITCH. When in NOR (guarded position) the BTR's will close as dictated by preferential and paralleling circuits. When in ISOL (isolate) position all four BTR's will be open.

BUS FAULT RESET SWITCH. Actuation of this switch to the RESET position will return the corresponding BTR to normal operation, should a fault have caused the BTR to trip and lock out.

GENERATOR UNPARALLELED LIGHT. (Amber, press to test). Illuminates when the BTR or GR for the corresponding generator is open, to indicate that the generator is not supplying the AC tie bus.

GENERATOR CONTROL SWITCH. Controls the generator relay (GR) of the corresponding generator. In OFF position, the GR will always be open. In ON position, the GR will be automatically controlled and will normally be closed. The switch is lever-locked in ON and OFF.
The momentary-contact RESET position is used to reset the generator field relay (if open).

AC LOADMETER. Indicates generator output in terms of generator rating. 1.0 corresponds to 30 KVA.

GENERATOR OVERLOAD LIGHT. (Amber, press to test). Illuminates if any AC loadmeter reading exceeds approx. 1.0 on ground or 1.27 in flight.

EMERGENCY ELECTRICAL CONTROL SWITCH. Controls the LMR to be closed with the switch in BUS POWER NORMAL (lever-locked) position and open with switch in BUS POWER OFF position.

BUS POWER FAILURE LIGHT. (Amber, press to test). Illuminates when the corresponding LMR has opened, indicating loss of power to associated bus.

DC LOADMETER. Indicates current drawn from the corresponding TR, in terms of TR rating.

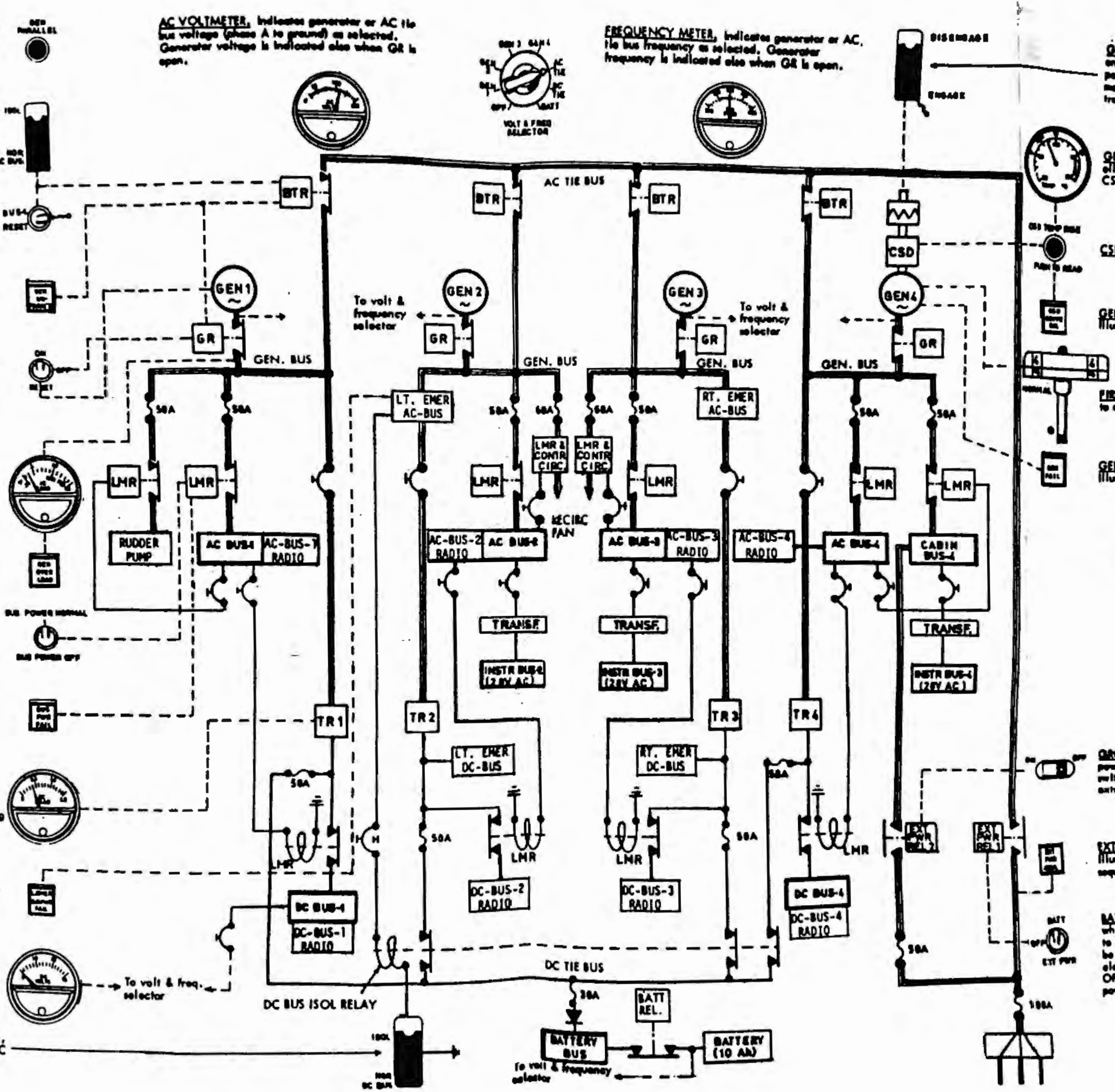
EMERGENCY BUS POWER FAILURE LIGHT. (Red, press to test). Illuminates together with the master warning light in case of power loss to the corresponding emergency AC bus.

DC VOLTMETER. Indicates voltage of DC tie bus or battery as selected by the volt and frequency selector.

DC BUS ISOLATION SWITCH. When in NOR (guarded) position, the DC bus isolation relay will be closed provided left emerg. AC bus is energized. When placed in ISOL (isolate) position or if power from left emerg. AC bus fails, the relay will open and separate the DC system into four sections.

AC VOLTMETER. Indicates generator or AC tie bus voltage (phase A to ground) as selected. Generator voltage is indicated also when GR is open.

FREQUENCY METER. Indicates generator or AC tie bus frequency as selected. Generator frequency is indicated also when GR is open.



GENERATOR DISCONNECT SWITCH. (Guarded in engage position). When momentarily actuated to DISENGAGE position, the corresponding constant speed drive transmission is mechanically disengaged from the engine drive. The CSD transmission cannot be reengaged during flight.

GEN. DRIVE OIL TEMPERATURE INDICATOR. Indicates CSD oil outlet temperature and also the temperature rise across the CSD when depressing the test button.

CSD TEMPERATURE RISE TEST BUTTON.

GEN. DRIVE OIL PRESSURE LIGHT. (Amber, press to test) Illuminates in case of low oil pressure in CSD.

FIRE SELECTOR. Opens generator field relay when moved to dot.

GENERATOR FAILURE LIGHT. (Amber, press to test). Illuminates in case of a generator bearing failure.

▬▬ 115V AC supply (3-phase)
── 1-phase AC supply
── 28V DC supply
── Control circuits

GEN	Generator
GR	Generator relay
BTR	Bus tie relay
LMR	Load monitor relay
TR	Transformer rectifier

GROUND SERVICE SWITCH. When the battery-external power switch is OFF and external power is connected, this switch can be used to energize cabin bus-4 from the external power source.

EXT. PWR AVAILABLE LIGHT. (Blue, press to test). Illuminates when an external power source of correct phase sequence is connected to the aircraft.

BATTERY-EXT. PWR SWITCH. When in BATT position, which is normal during flight, the battery will be connected to the battery bus. In EXT PWR position external power will be supplied to the AC tie bus and energize the entire electrical power system. Battery relay will then be open. OFF position disconnects both the battery and the external power from the buses.

1. Main Description and Operation

A. General (See Figure 29-1)

(1) Description

(a) The hydraulic power system receives fluid pressure from the engine-driven hydraulic pumps, one installed on each inboard engine. The electrically driven auxiliary pump is used to supplement the engine-driven pumps, or to independently supply the system with fluid pressure.

(b) The hydraulic system reservoir, located in the left wing root, has a total volume of approximately 14.4. US gallons. Approximately 9/10 of the reservoir is used for fluid, and 1/10 is used for foam space. A separate air chamber is installed in the reservoir system to provide for a greater fluid capacity in the main reservoir. A reservoir filler assembly is installed in the piping between the reservoir and the air chamber and has a vent line from the filler neck to the tee at the top of the reservoir sight gage. The reservoir is pressurized to 30 to 35 psi by bleed pressure from the engine-driven pumps through an air pressure regulator-aspirator.

(c) The engine-driven pumps receive fluid from the pressurized main reservoir through respective engine hydraulic fire shutoff valves. The engine hydraulic fire shutoff valves are normally open and can be mechanically controlled from the flight compartment. The pumps supply fluid pressure through respective check valves to the dual filter and relief valve. Some of the fluid from the filter is ported through the regulator-aspirator to pressurize the reservoir. Most of the fluid is routed through a check valve to the system selector valve, and then to the left and right hydraulic power manifolds. The manifolds distribute the fluid pressure to the subsystems.

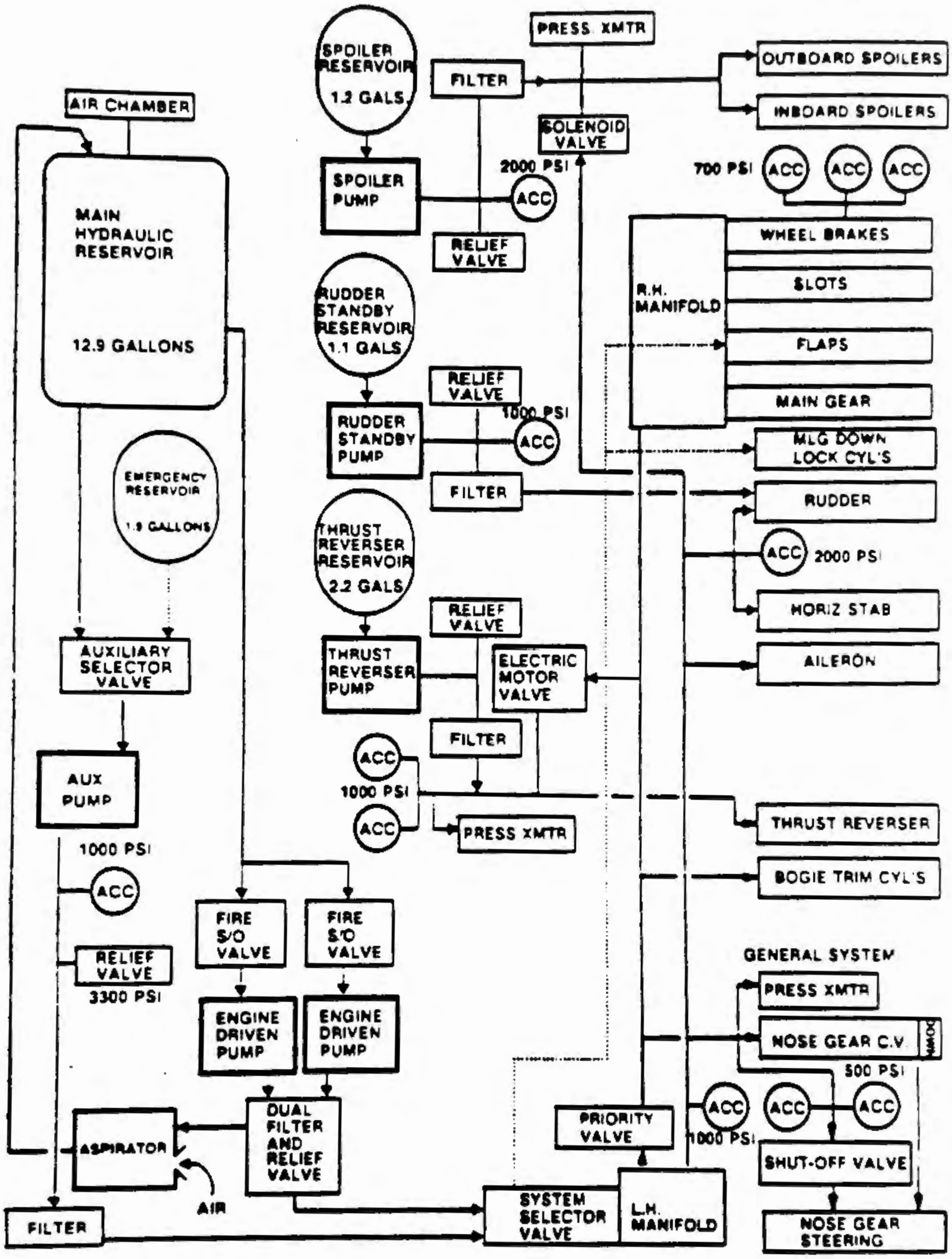
(d) Hydraulic fluid is normally supplied to the auxiliary hydraulic pump from a low standpipe in the main reservoir. During alternate operation, the auxiliary hydraulic pump receives fluid supply from the auxiliary pump alternate reservoir, which is located just aft of the auxiliary pump. From these reservoirs, the fluid is ported through the auxiliary pump selector valve which is mechanically controlled from the flight compartment by the system selector control lever. When operating, the auxiliary hydraulic pump supplies fluid pressure to the subsystems through the system selector valve which is also controlled by the system selector control lever in the flight compartment. A filter and check valve are installed in the line form the auxiliary pump to the system selector valve.

(e) An accumulator is installed in the pressure line to the subsystems to provide a reserve supply of fluid and to act as a surge damper for the system.

(f) Engine-driven pump fluid pressure is routed through the system selector valve to the left power manifold, where it is distributed to some of the subsystems and through the priority valve to the right power manifold. Fluid pressure from the right power manifold is distributed to the remaining subsystems.

(g) The priority valve is a spring-loaded, poppet-type, balanced relief valve installed in the line downstream of the left power manifold. The priority valve's function in the system is to prevent the flight control systems from reverting to manual operation during high demands on the hydraulic system.

(h) A fluid pressure transmitter, located in the nosewheel well, senses the system pressure, which is indicated on the hydraulic system pressure indicator in the flight compartment.



HYDRAULIC POWER SUPPLY - BLOCK DIAGRAM

FTX80060

Figure 29-1

(2) Normal Operation

(a) Fluid is supplied to the hydraulic system from the pressurized hydraulic system reservoir. For operation of the hydraulic system under normal conditions, 8.1 US gallons of hydraulic fluid are available to the engine-driven hydraulic pumps, and 12.9 US gallons are available to the auxiliary hydraulic pump. Supply lines from the main reservoir carry fluid to each inboard pylon through normally open engine hydraulic fire shutoff valves to the engine-driven hydraulic pumps. Fluid is supplied to the auxiliary hydraulic pump from the main reservoir through a low standpipe at the base of the reservoir. Fluid is carried from the reservoir through the auxiliary pump selector valve to the auxiliary hydraulic pump.

(b) The engine-driven hydraulic pumps supply full system pressure (3000 psi nominal) as any given engine speed, from idle to full power. The output flow of the pump is varied by sensing pressure from the outlet side of the pump. Each engine-driven pump contains a solenoid-operated bypass valve which, when energized, bypasses the pressure control regulator of the pump and ports fluid to the pump yoke control piston which feathers the pump. When the pump is feathered, flow rate is reduced to almost zero (1.0 gpm) and to a pressure of approximately 700 psi. Half of this flow maintains pump lubrication and cooling through a check valve, the engine-driven pump case drain line filter, and another check valve to the case drain return port of the reservoir. The pressure fluid from each pump passes through a check valve to the dual filter and relief valve.

(c) The fluid enters the dual filter and relief valve through the relief valve chamber. The fluid is passed through the filter element, through a manifold, and through a common outlet port. Fluid from the outlet port is routed through a check valve to the system selector valve. If back pressure in the system builds up to approximately 3300 psi, the relief valves in the dual filter and relief valve open and port fluid back to the reservoir via A return port. The relief valve poppet closes again when system pressure drops to approximately 3000 psi.

(d) The aspirator receives filtered fluid (bleed pressure at nominal 3000 psi) from the dual filter and relief valve. The aspirator operates on the jet pump principle. Hydraulic fluid is atomized and mixed with air within tbe unit by a nozzle and a venturi. The mixture is used to pressurize the reservoir and reservoir air chamber. The regulator diaphragm maintains a pressure range of 30 to 35 psi in the reservoir and air chamber. If there is a regulator malfunction, the aspirator stalls when the outlet pressure reaches a maximum of 40 psi. A reservoir relief valve in the reservoir vent line relieves thermal expansion pressure above 45 (+5, -0) psi.

(e) Pump pressure fluid enters the system selector valve through the system pressure inlet port. When the pump selector control lever is in the general system (normal) position, fluid is ported to the pressure passages of the left power manifold. The fluid pressure in the left power manifold is ported through the priority valve to the nose gear and the right power manifold and directly to the following valves:

1 Aileron power shutoff

2 Rudder power shutoff

3 Longitudinal trim hydraulic motor shutoff

(f) The right power manifold distributes fluid pressure to the brake accumulators, the pressure transmitter, and the following control valves:

1 Wing flap

2 Slot

3 Main gear

4 Power brake

(g) The return fluid from the wing flap control valve is ported through the right power manifold and into the auxiliary hydraulic pump alternate reservoir. Return fluid from the outboard wing flaps is piped into the suction lines for each engine-driven hydraulic pump. Return fluid from the slot control valve is ported into the A return line to the main reservoir. The power brake and main gear control valve gear up return fluid is ported through a restrictor check valve into the B return line to the reservoir. The main gear control valve gear down return pressure bypasses the right manifold and returns to the reservoir through the A return line. All return fluid entering the reservoir is filtered through the return ports filter located within the reservoir.

(3) Bypass Operation

(a) The output of the engine-driven hydraulic pumps is bypassed by moving the system selector control lever out of the general system (normal) position to the bypass/general system position.

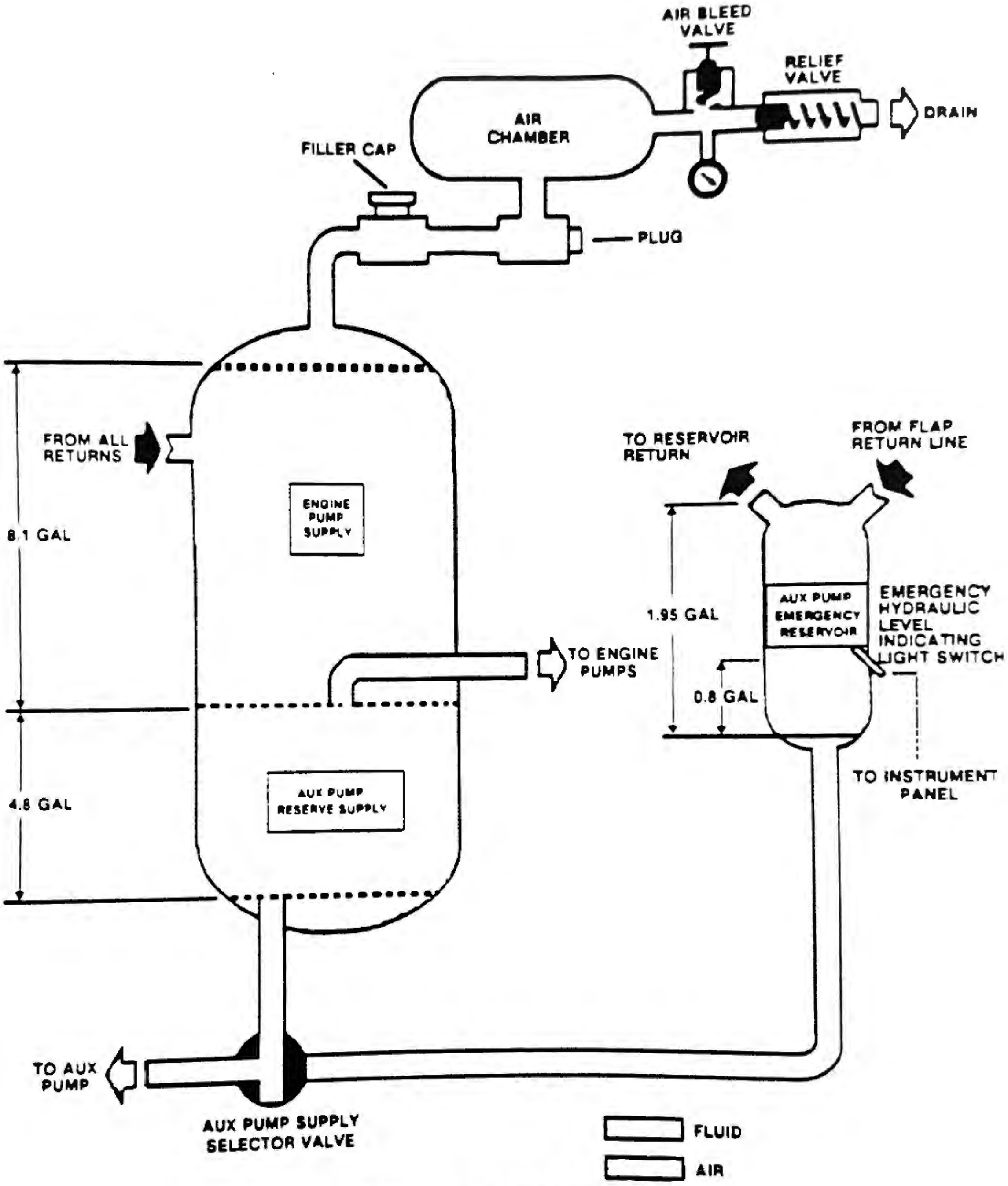
(b) The system selector valve in the bypass position ports engine-driven pump pressure from the dual filter and relief valve directly to the return passage of the left power manifold. From the manifold, the fluid is ported directly to a tee in the wing flap return port of the hydraulic system reservoir. In the bypass condition, the auxiliary hydraulic pump receives fluid from the hydraulic system reservoir, pressurizes it to system pressure, and ports it to the left and right power manifolds for distribution to the subsystems.

(4) Alternate Operation (See Figure 29-2)

(a) When both engine-driven hydraulic pumps and the auxiliary hydraulic pump are rendered inoperative due to the loss of the normal supply of fluid, the hydraulic power system can be rigged for alternate operation. This is accomplished by placing the system selector control lever in the general system/main gear downlock and flaps position. When the system selector control lever is in this position, the auxiliary hydraulic pump supply selector valve is positioned to supply fluid from the auxiliary pump alternate reservoir to the auxiliary pump.

(b) Fluid is supplied to the auxiliary pump from the outlet port of the auxiliary pump supply selector valve. Output pressure is ported through the auxiliary system filter and check valve to the auxiliary pressure inlet port of the system selector valve.

(c) In the general system/main gear downlock and flaps position, auxiliary pump pressure bypasses the manifold pressure passages and is ported from the alternate outlet port of the system selector valve. Fluid from this port flows directly to a port on the right power manifold, through an internal check valve in the manifold, to the wing flap control valve. A line, teed into the alternate supply line, runs directly to a shuttle valve in the main gear downlock cylinder line. When auxiliary pressure is applied, the shuttle valve shifts, porting fluid into the downlock bungee cylinder's downlock side.



HYDRAULIC RESERVOIR

FTX80064

Figure 29-2

(5) Mechanical Control (See Figure 29-3)

(a) The hydraulic power mechanical control system consists of the hydraulic system selector control lever cable drum, the system selector valve sector, the system selector valve, the auxiliary hydraulic pump supply selector valve.

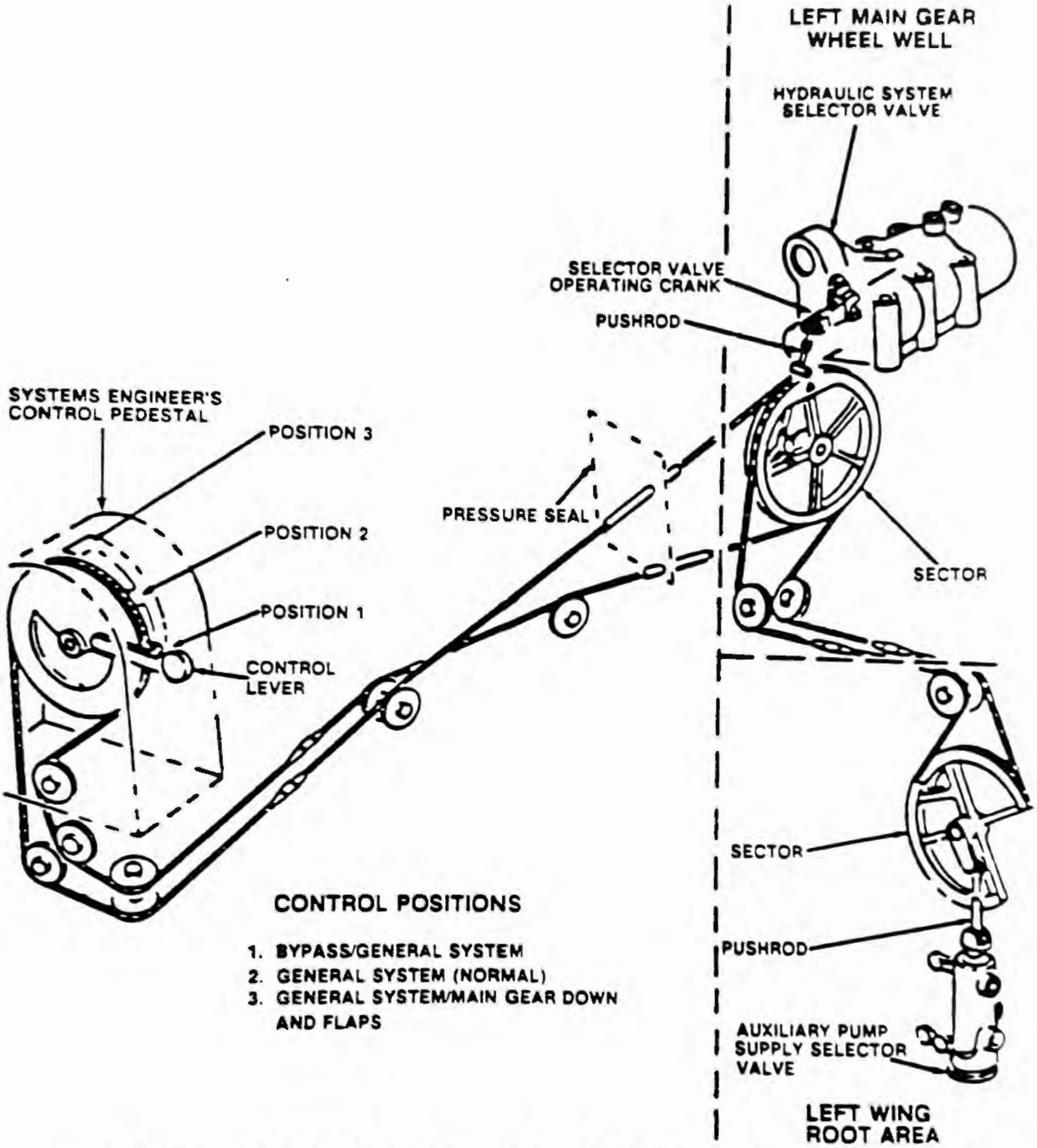
(b) The control lever located on the system engineer's control pedestal is used to position the system selector valve and, in turn, the auxiliary hydraulic pump supply selector valve.

(c) The control lever is spring loaded into general system (normal) position, and is connected to the control lever cable drum. Two cables run from the drum, under the cabin floor, aft through the pressure bulkhead at the rear wing spar, and into the left wheel well to the system selector valve sector. A pushrod connects the sector to the positioning lever of the system selector valve.

(d) A second set of cables is routed from the system selector valve sector into the left wing root to the auxiliary hydraulic pump supply selector valve sector. When the system selector valve is in either bypass or normal, the auxiliary hydraulic pump supply selector valve sector is arranged so that the pushrod idles between the two positions. This allows the valve to remain in the auxiliary position. When the sector is moved to the alternate position, the pushrod is pulled by the sector to reposition the valve to the alternate position.

(e) The control lever is normally in the general system (normal) position. To move the system selector valve to the bypass position, the control lever is moved to the bypass/general system position. When the system selector valve is moved to the bypass position, the auxiliary hydraulic pump supply selector valve sector is moved to a new position. Due to the idle feature on the auxiliary sector, the valve remains in the auxiliary position. With the valve in this position, fluid is supplied to the auxiliary pump through the low standpipe in the hydraulic system reservoir. In this condition, engine-driven pump pressure is ported to the reservoir and the auxiliary pump pressure is ported to the general system.

(f) To put the system is alternate operation, the control is moved to the general system/main gear downlock and flaps position. This moves the system selector valve to the alternate position, and simultaneously moves the auxiliary hydraulic pump supply selector valve to the alternate position. Fluid is supplied to the auxiliary pump from the auxiliary hydraulic pump alternate reservoir. Fluid pressure from the auxiliary pump is ported to the flap system control valve and the main gear downlock cylinders. Engine-driven pump pressure is ported from the system selector valve to the general system.


LEFT MAIN GEAR WHEEL WELL
HYDRAULIC SYSTEM SELECTOR VALVE
SELECTOR VALVE OPERATING CRANK
PUSHROD
SYSTEMS ENGINEER'S CONTROL PEDESTAL
POSITION 3
POSITION 2
POSITION 1
CONTROL LEVER
PRESSURE SEAL
SECTOR
SECTOR
PUSHROD
AUXILIARY PUMP SUPPLY SELECTOR VALVE
LEFT WING ROOT AREA
CONTROL POSITIONS
1. BYPASS/GENERAL SYSTEM
2. GENERAL SYSTEM (NORMAL)
3. GENERAL SYSTEM/MAIN GEAR DOWN AND FLAPS

HYDRAULIC SYSTEM SELECTOR AND AUXILIARY PUMP SUPPLY SELECTOR VALVES - MECHANICAL CONTROL SCHEMATIC

FTX80061

Figure 29-3

B. System Components

(1) Hydraulic System Reservoir (See Figures 29-4, 29-5 & 29-6)

(a) The hydraulic system reservoir is installed on the aft side of the wing rear spar in the left wing root and is accessible through the left wing root access door. The hydraulic system reservoir serves as the main source of hydraulic fluid for the engine-driven hydraulic pumps and the normal supply for the auxiliary hydraulic pump. The reservoir is cylindrical in shape and contains a filter, baffle, and a screen cover encasing the filter. The filter prevents foreign particles from contaminating the fluid supply. Mountings are provided on the exterior surface of the reservoir for return line ports, aspirator port, electrical sensing units, sight gage, instruction placards, magnetic drain plug, and system supply ports.

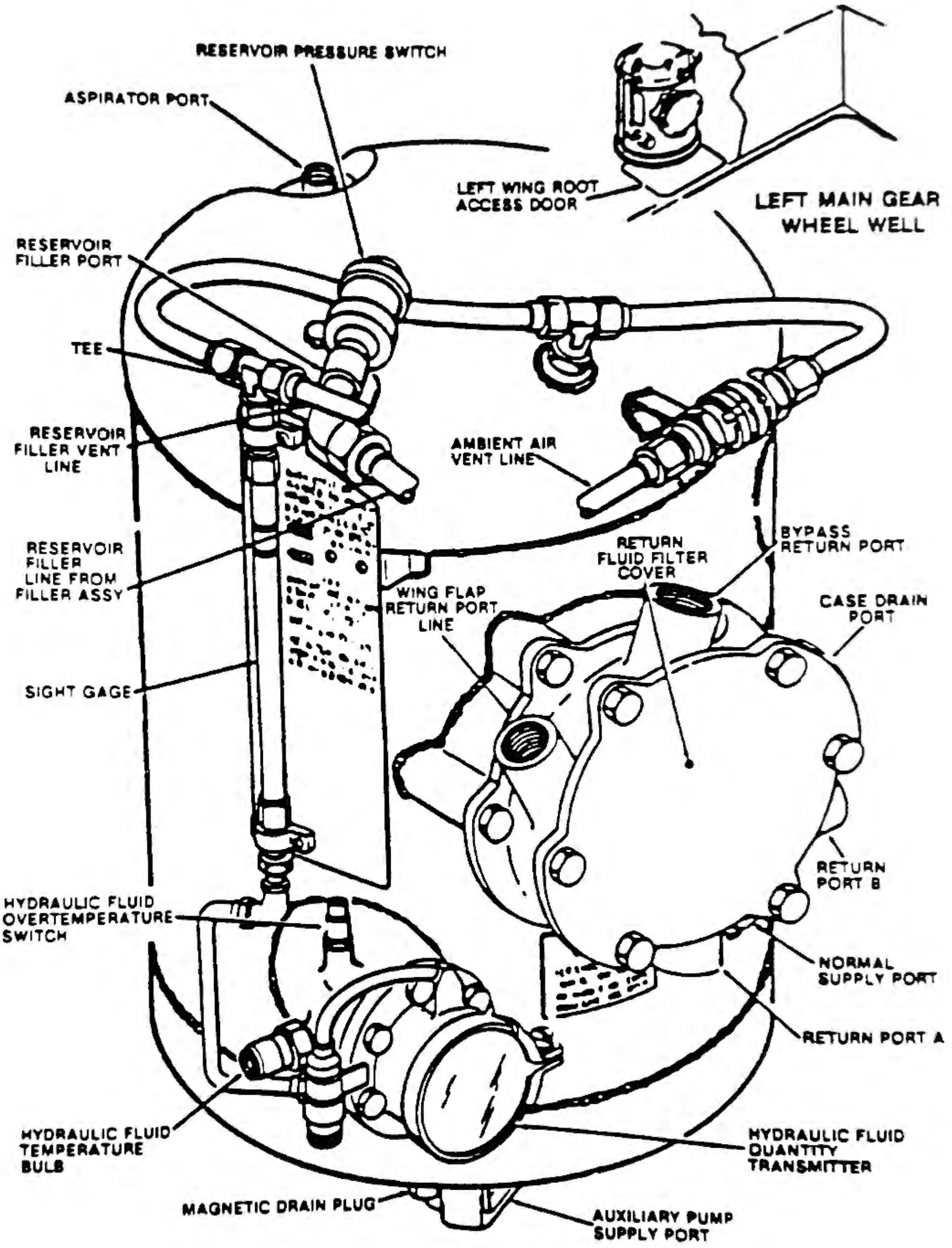
(b) The reservoir is pressurized with air from the regulator-aspirator to a range of 30 to 35 psi and has a total volume of approximately 14.4 US gallons. Approximately 9/10 of the reservoir volume is used for fluid and 1/10 is used for foam space.

(c) The aspirator port through which the reservoir is pressurized is located in the recess on top of the reservoir. An aspirator-deaerator filter is supported in the reservoir by a screen and support box assembly which is mounted to the reservoir wall by two bolts.

(d) The mounting flange for the return ports manifold is welded to the inboard side of the reservoir. The return ports manifold is an open-centered ring, flanged at both sides and provided with five fluid ports around its circumference; return port A is located at the bottom, return port B is located at the lower right side, the wing flap return port is located at the upper left side, and the system selector valve bypass port is located at the top. One flange of the manifold is mounted with six bolts to the mounting flange on the reservoir. The return fluid filter cover fits into the open side of the manifold, and is attached to the outer manifold flange with six bolts to form a fluid-tight cover for both the manifold and the filter.

(e) The return fluid filter is installed in the reservoir, behind the return ports manifold. A retaining spring attached to an eyebolt on the inner side of the return fluid filter cover holds the filter in position. A baffle plate is welded to the inside of the reservoir opening and to the engine pump supply standpipe within the reservoir. A screen that reduces aeration of the fluid is snap-mounted to two brackets that are welded to the baffle. The screen is U-shaped and is mounted so that it encloses the filter.

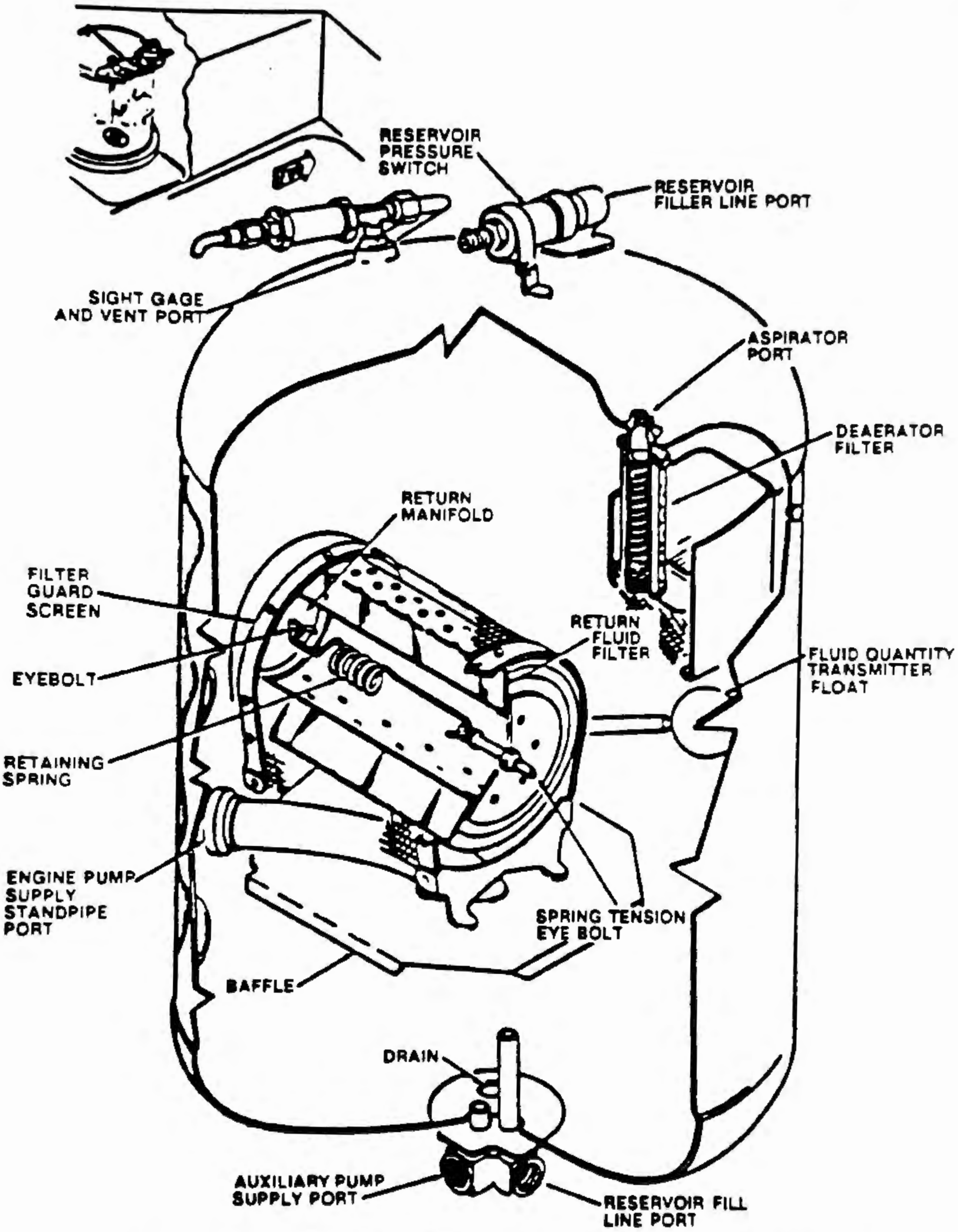
(f) A flanged adapter for the fluid quantity transmitter is welded to the reservoir below and to the left of the return ports manifold. The adapter is provided with two small port bosses for the hydraulic fluid temperature bulb and the hydraulic fluid overtemperature switch. The lower end of the sight gage connects to a third port in the adapter, while the top of the sight gage tees into a port at the top of the reservoir. An instruction plate is mounted behind the sight gage and the vacuum breaker check valve tees into the port at the top of the reservoir that is used by the sight gage.


RESERVOIR PRESSURE SWITCH
ASPIRATOR PORT
LEFT WING ROOT ACCESS DOOR
LEFT MAIN GEAR WHEEL WELL
RESERVOIR FILLER PORT
TEE
RESERVOIR FILLER VENT LINE
AMBIENT AIR VENT LINE
RESERVOIR FILLER LINE FROM FILLER ASSY
RETURN FLUID FILTER COVER
BYPASS RETURN PORT
WING FLAP RETURN PORT LINE
CASE DRAIN PORT
SIGHT GAGE
RETURN PORT B
HYDRAULIC FLUID OVERTEMPERATURE SWITCH
NORMAL SUPPLY PORT
RETURN PORT A
HYDRAULIC FLUID TEMPERATURE BULB
HYDRAULIC FLUID QUANTITY TRANSMITTER
MAGNETIC DRAIN PLUG
AUXILIARY PUMP SUPPLY PORT

HYDRAULIC SYSTEM RESERVOIR - EXTERNAL VIEW

FTX80062

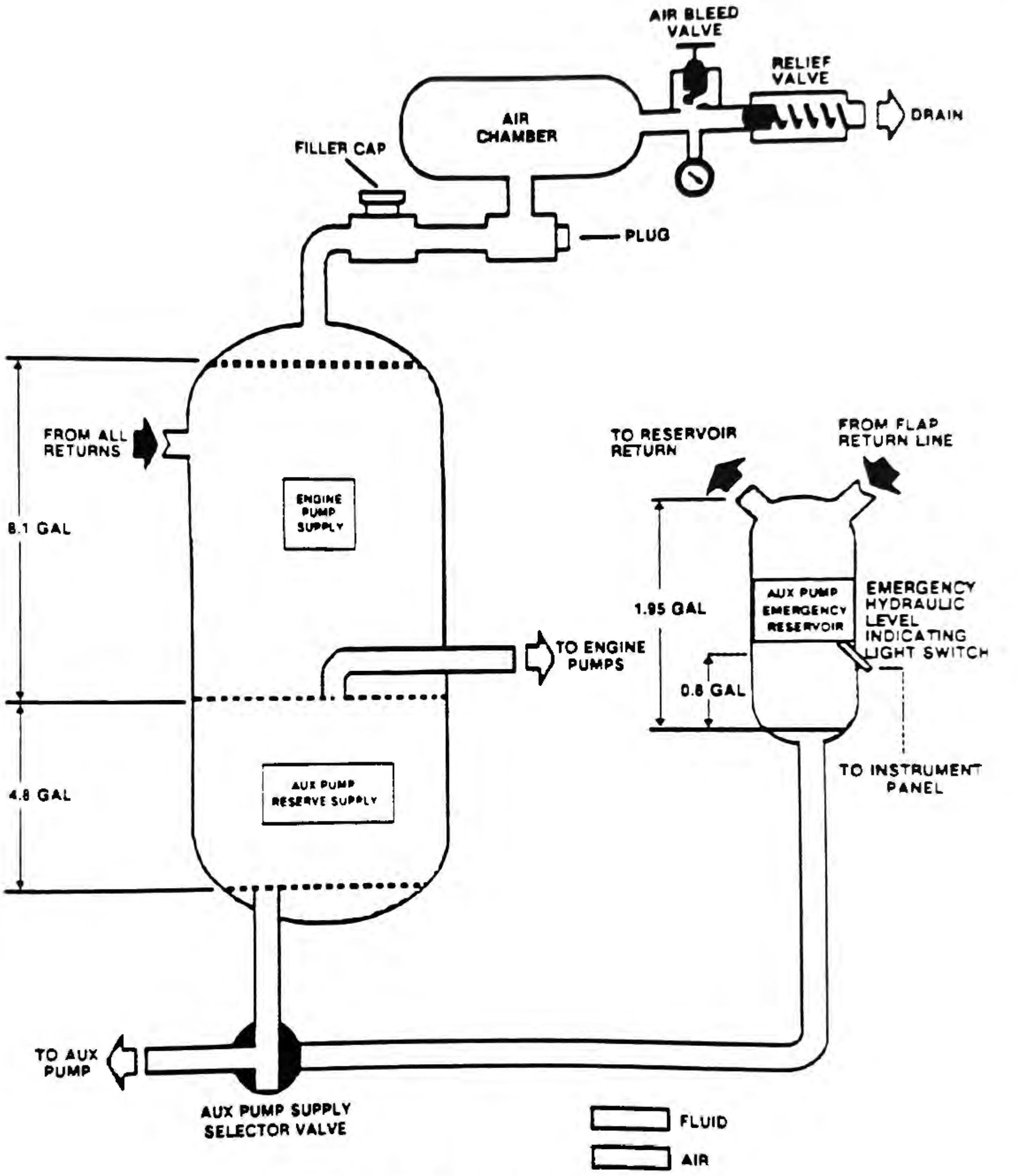
Figure 29-4



HYDRAULIC SYSTEM RESERVOIR - CUTAWAY VIEW

FTX80063

Figure 29-5



HYDRAULIC RESERVOIR

FTX80064

Figure 29-6

(2) Hydraulic Reservoir Return Fluid Filter (See Figure 29-4)

(a) The reservoir return fluid filter is installed in the hydraulic reservoir to prevent foreign matter from contaminating the fluid supply. The filter is located behind the return ports manifold. and is spring loaded to act as its own relief valve. Access to the filter is by removing the return fluid filter cover from the return ports manifold by removal of six bolts. The filter is attached by the retaining spring to the cover and is withdrawn from the reservoir when the cover is removed.

(b) Externally, the filter consists of two perforated concentric tubes. The area between the tubes is closed by metal end caps which are bonded to the two tubes. A resilient rubber gasket is bonded to each of the caps. Each gasket must be smooth and flat for proper sealing of the filter. The gaskets act as a static seal and a relief valve seat.

(c) Internally, the filter has a 10-micron, resin-impregnated, convoluted paper-type filter element. The area of the filter element is approximately 1960 square inches. The filter is held in place by a retaining spring. One end of the spring is attached to an eyebolt located inside the return port's manifold cover. The spring passes through the center chamber of the filter and is connected to another eyebolt. This eyebolt is secured to a large washer and plate by means of a self-locking nut. The washer seats on the rubber gasket which is bonded to the filter. The fluid enters the center chamber of the filter and passes through the inner tube of the filter to the filter element by means of perforation holes. Foreign matter is filtered out by the filter element, and the fluid leaves the element through perforation holes in the outer tube. When the element becomes saturated with foreign matter, the filter acts as its own relief valve and unseats at 20 to 25 psi above normal return pressure which allows fluid to bypass the filter and enter the reservoir.

(3) Hydraulic Reservoir Air Pressure Regulator-Aspirator (See Figure 29-7)

(a) The reservoir air pressure regulator-aspirator is a jet-type air pump, regulated by a pressure-sensitive shutoff valve. The unit pressurizes the hydraulic reservoir with air to the operating pressure range of 30 to 35 psi. The regulator-aspirator is located on the top inboard side of the reservoir and is mounted on the reservoir retainer ring. Access to regulator-aspirator is through the left wing root access door.

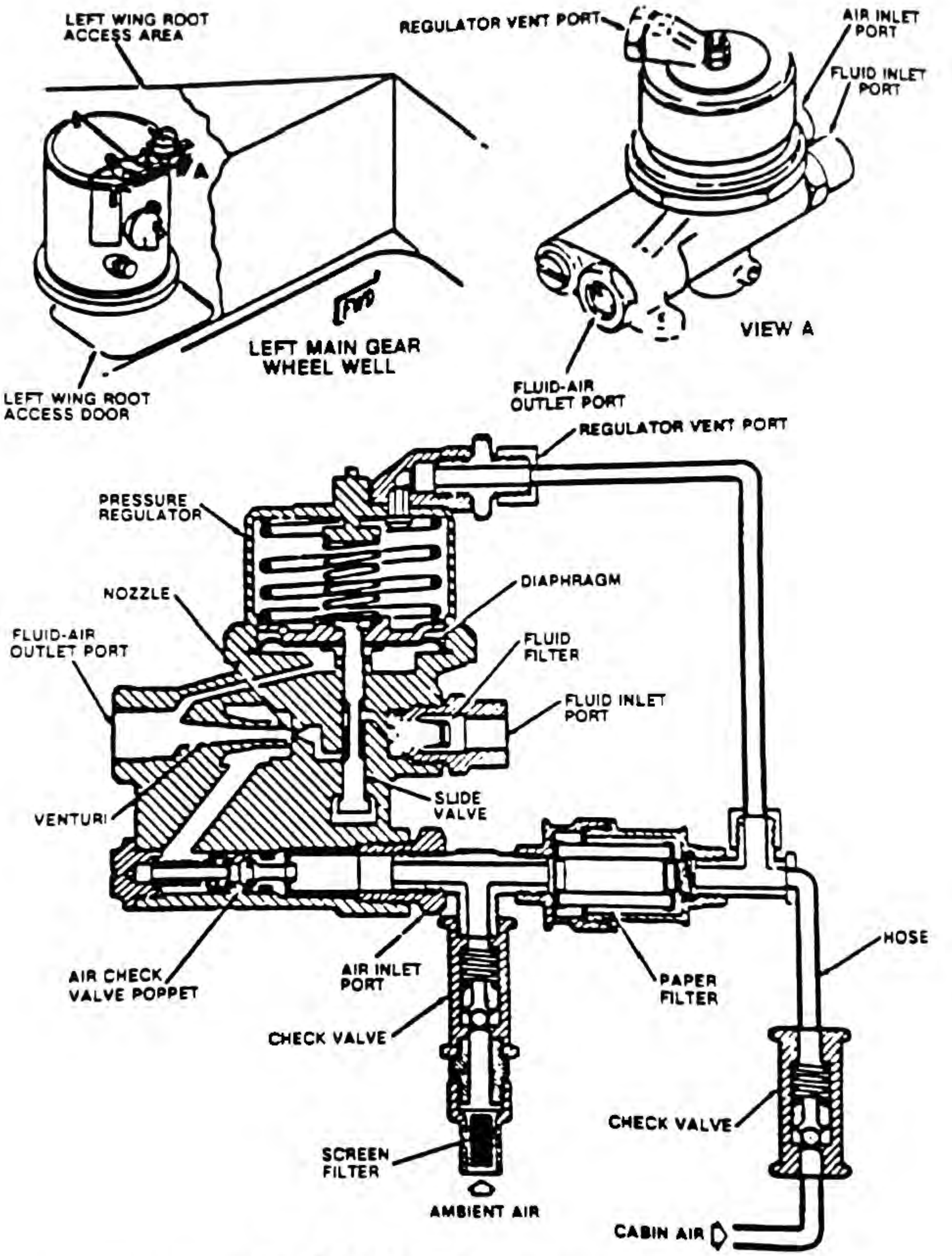
(b) The regulator-aspirator assembly consists of a main aspirator body and a regulator housing. The main aspirator body has two inlet ports and one outlet port. The ports are permanently identified inlet, outlet, and air inlet. The plug for an air check valve is located near the outlet plug. A chemically treated paper filter is installed near the aspirator body air inlet port in the air line from the pressurized cabin area. A metal screen filter is installed on the check valve which tees into the aspirator body air inlet port.

(c) The reservoir air pressure regulator-aspirator operates basically with a jet pump action which is regulator controlled. Fluid enters the assembly through the fluid inlet port where it is filtered and then ported through the valve assembly of the regulator. During normal operation, when air pressure at the outlet port is under 30 psi, the valve is open, porting fluid to the nozzle. The orifice in the nozzle sprays the fluid through the venturi of the outlet port, creating a vacuum in the chamber around the venturi. When the vacuum becomes great enough to create a pressure differential of approximately 1 psi, ambient air opens the air check valve. The air is ported to the chamber around the venturi and is siphoned, with the fluid, through the outlet port.

(d) Hydraulic fluid inlet pressure at the engine-driven hydraulic pumps is improved at high altitude operation by supplying pressurized filtered cabin air to the reservoir regulator-aspirator instead of ambient outside air. Part of the inlet air is diverted by a tee fitting to the regulator chamber to provide a more positive regulating force on the diaphragm than would be obtained with low ambient pressures. The chemically treated paper filter, installed in the regulator-aspirator air supply line from the cabin, removes smoke tars and impurities from the pressurized cabin air. The steel mesh screen filter, installed on the check valve which tees into the regulator-aspirator air inlet port downstream of the paper filter, removes dust, dirt, and foreign particles from the ambient air and serves as a standby to supply filtered air in event the paper filter is clogged.

(e) As pressure in the reservoir builds up, back pressure is bled from the outlet port to the diaphragm chamber. The reaction on the diaphragm begins to move the slide valve to cut off the fluid flow. At 30 to 35 psi of back pressure, the diaphragm completely closes the slide valve, cutting off the flow of fluid. If there is a regulator malfunction, the aspirator stalls when outlet pressure reaches a maximum of 40 psi.

(f) The aspirator is capable of pressurizing the reservoir to 30 to 35 psi in approximately 4 minutes at altitudes from sea level to 15,000 feet, when fluid is ported through the nozzle at 0.5 gpm at 3000 psi.



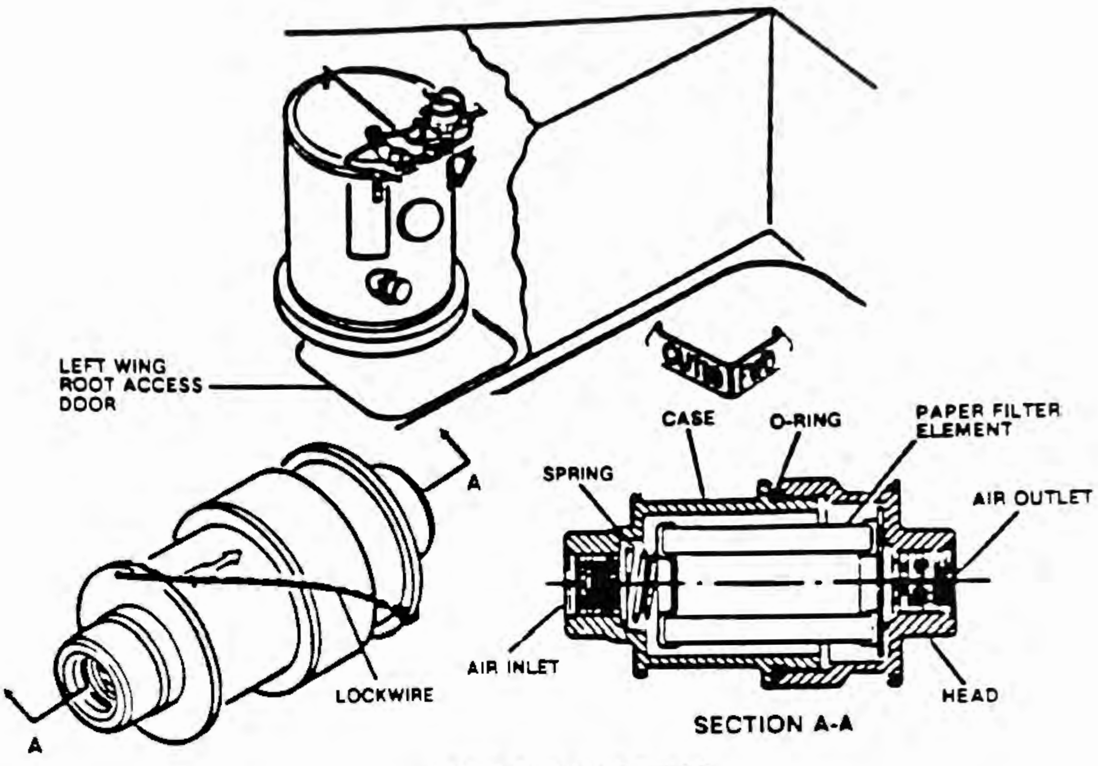
RESERVOIR AIR PRESSURE REGULATOR-ASPIRATOR

FTX80065

Figure 29-7

(4) Regulator-Aspirator Air Filters (See Figure 29-8)

(a) The regulator-aspirator air filters remove ambient and cabin air impurities from the air which is used to pressurize the main hydraulic system reservoir. The filtering system is composed of two filters. One of which is a paper element filter, installed directly in the cabin air supply line near the regulator-aspirator. The outer filter is a fine mesh, screen-type filter, installed on a check valve and positioned at right angles to the regulator-aspirator air inlet port. The screen filter, in addition to providing an immediate supply of ambient air during ground operations, serves as a standby air inlet to preclude air starvation of the regulator-aspirator in the event the paper element filter becomes clogged.



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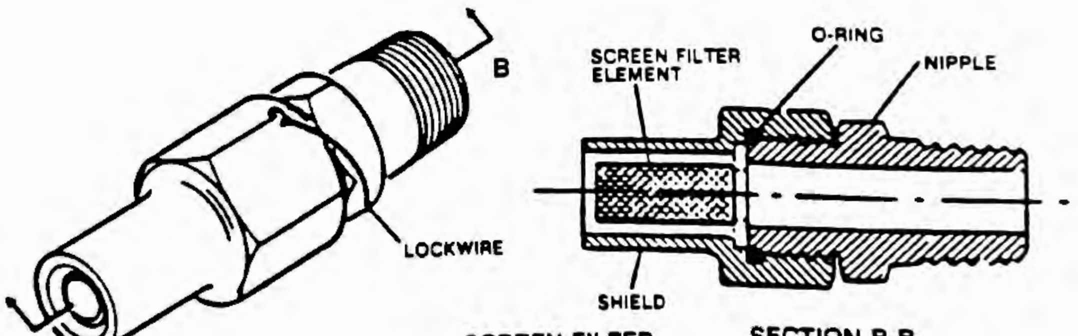


SCREEN FILTER

REGULATOR-ASPIRATOR AIR FILTERS – CUTAWAY VIEW

FTX80066

Figure 29-8

(5) Hydraulic Reservoir Relief Valve (See Figures 29-9 & 29-10)

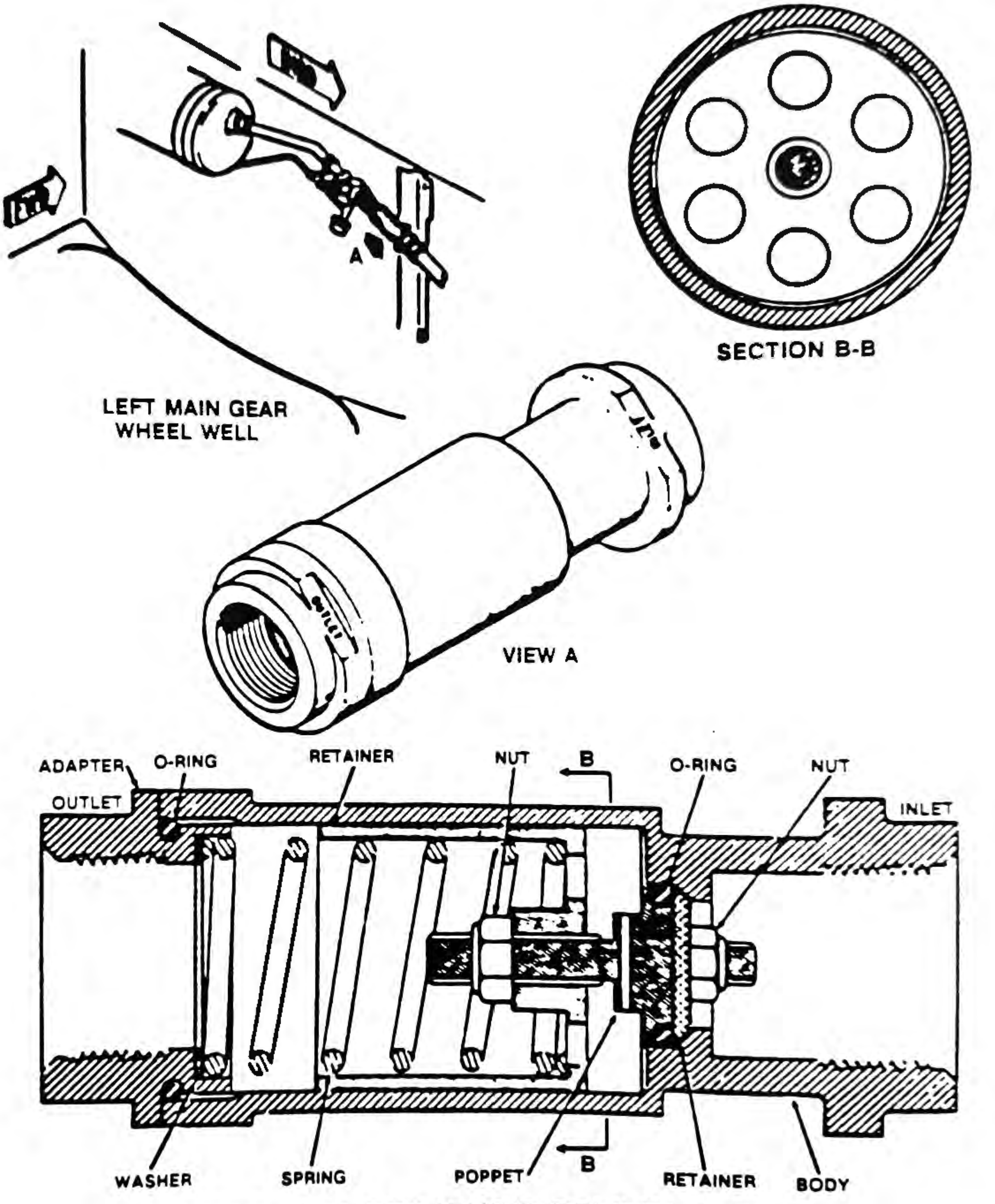
(a) The reservoir relief valve and the air pressure aspirator-regulator keep the reservoir pressurized to normal operating range. The valve relieves excess air pressure which may build up in the reservoir through thermal expansion in the system. The valve has an inlet port and an outlet port and consists, internally, of an inlet port seat and a spring-loaded poppet.

(b) The relief valve is installed in the overboard vent line downstream of the hydraulic reservoir air bleed valve. In the event that excess pressure builds up in the reservoir, the poppet will start to relieve at 45 (+5, -0) psi. Full flow of 10 gpm is attained at 80 psi maximum.

(c) The hydraulic reservoir air bleed valve and pressure gage are located in the aft side of the rear spar in the left main gear wheel well, inboard of the hydraulic reservoir air chamber. The bleed valve and gage are installed in the overboard vent line, between the reservoir air chamber and the reservoir relief valve.

(d) The bleed valve is used to relieve the reservoir air pressure prior to disconnecting lines or components in the hydraulic system. The pressure gage provides a ready indication of the hydraulic reservoir air pressure and is used in conjunction with the bleed valve to indicate the air pressure status.

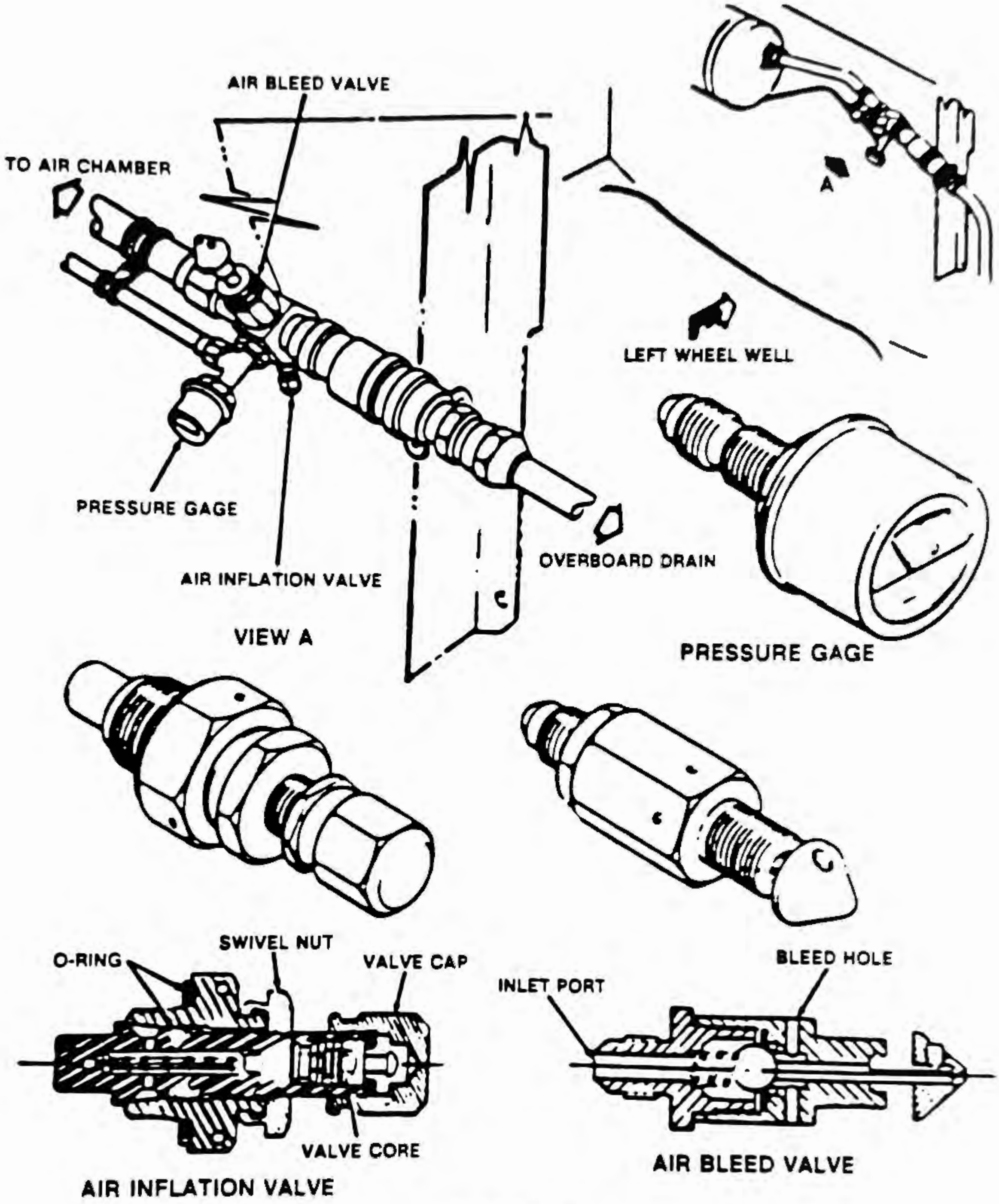
(e) The air inflation valve is installed on the same fitting as the bleed valve and pressure gage. The air inflation valve is used to manually charge the reservoir with air or dry nitrogen.



HYDRAULIC RESERVOIR RELIEF VALVE

FTX80067

Figure 29-9



VALVES

FTX80068

Figure 29-10

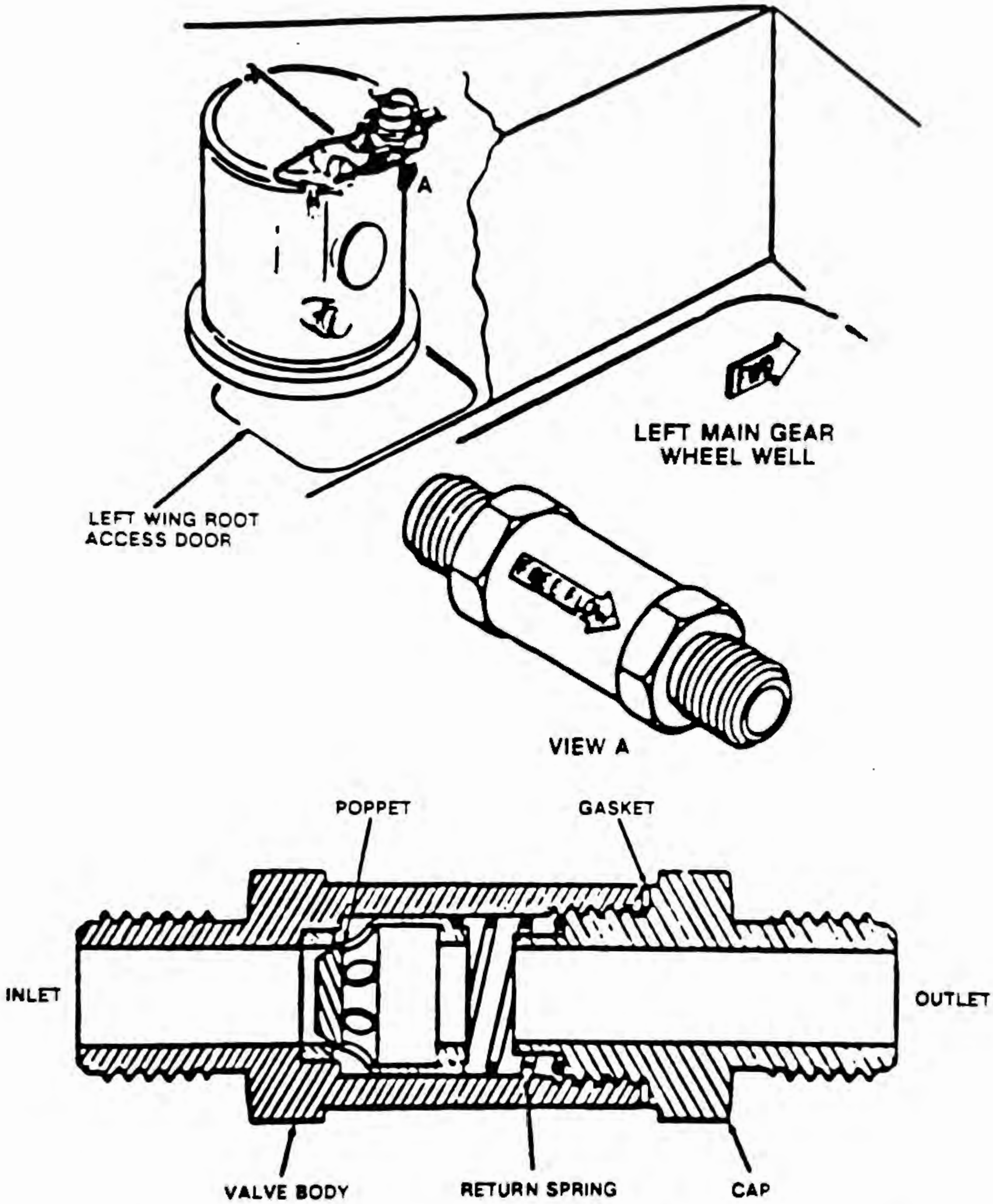
(6) Hydraulic Reservoir Vacuum Breaker Check Valve (See Figure 29-11)

(a) The hydraulic reservoir vacuum breaker check valve is installed on the regulator-aspirator mounting bracket, and connects to the tee fitting at the top of the reservoir. The valve is vented to ambient air. The purpose of this valve is to maintain atmospheric pressure in the reservoir, allowing hydraulic fluid to flow to the auxiliary hydraulic pump in the event of a failure of the reservoir pressurization system. The failure, or breakdown, of the pressurization system could cause a fluid starvation at the auxiliary hydraulic pump because of vacuum buildup in the reservoir.

(7) Hydraulic Reservoir Air Chamber

(a) The hydraulic reservoir air chamber is a small, cylindrical tank with a capacity of 700 cubic inches. It has two ports, an inlet port at the bottom of the chamber and an outlet port in one end of the chamber. The inlet port mounting boss is fitted with a drain plug. The air chamber is installed on the aft side of the rear spar in the left main gear wheel well, inboard and above the hydraulic reservoir filler assembly. Access to the air chamber is through the left main gear inboard door.

(b) The air chamber provides for greater fluid capacity in the hydraulic reservoir by providing air and foam space for the reservoir in a separate container. Air pressure in the chamber is maintained by the regulator-aspirator and the air relief valve. The air pressure in the chamber and reservoir can be relieved, when desired, by the air bleed valve located downstream of the chamber. The air chamber is mounted higher than the reservoir filler assembly, to prevent overfilling of the reservoir from reducing the available air space and to prevent fluid from being vented overboard through the reservoir relief valve.



HYDRAULIC RESERVOIR VACUUM BREAKER CHECK VALVE

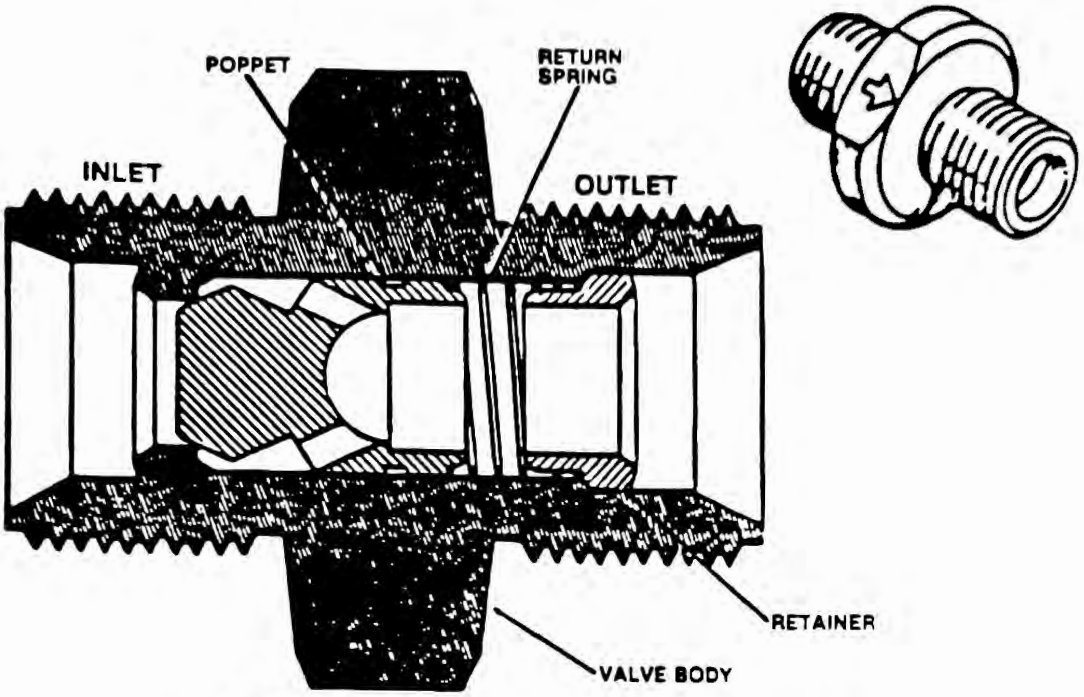
FTX80069

Figure 29-11

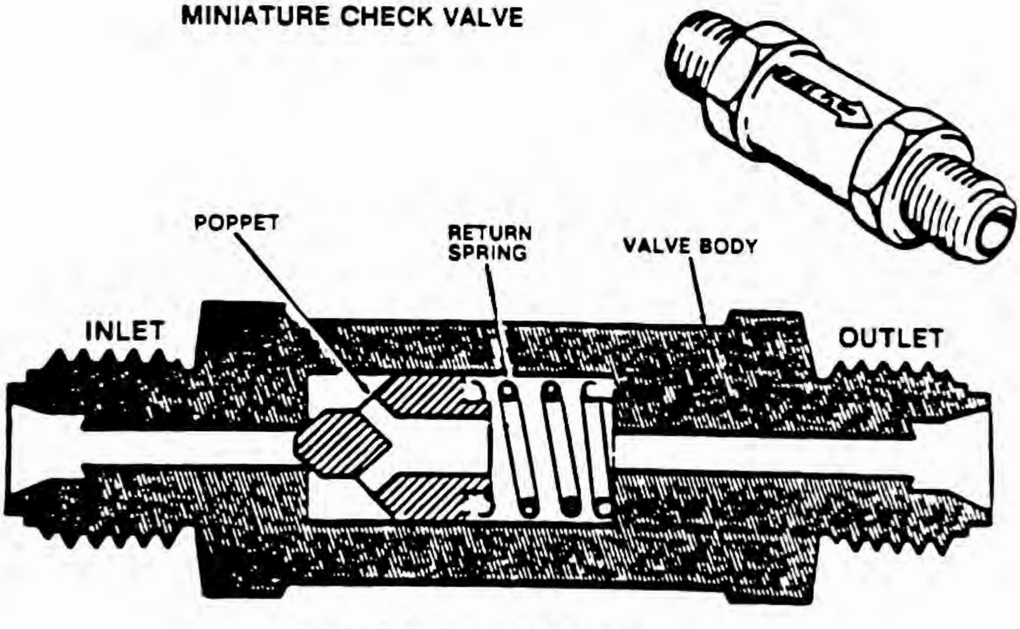
(8) Hydraulic Reservoir Port B Return Check Valve (See Figure 29-12)

(a) The reservoir port B return check valve is installed in port B of the reservoir to prevent reverse flow of hydraulic fluid from the reservoir to the return line. The check valve is located on the reservoir in the left wing root and is accessible through the left wing root access door.

(b) Externally and internally, the port B check valve is a standard-type check valve with a 1500-psi rating. A nominal pressure of approximately 8 psi unseats the poppet, permitting fluid to flow through the valve. When the reservoir pressure exceeds the return line pressure, the poppet will seat and reverse fluid flow will be prevented.



MINIATURE CHECK VALVE



STANDARD CHECK VALVE

HYDRAULIC CHECK VALVES - TYPICAL

FTX80070

Figure 29-12

(9) Engine Hydraulic Fire Shutoff Valve (See Figures 29-13 & 29-14)

(a) The engine hydraulic fire shutoff valve is a gate-type, mechanically controlled valve, installed in the supply line of each engine-driven hydraulic pump. The engine hydraulic fire shutoff valve is actuated from the flight compartment to prevent the flow of hydraulic fluid into the engine section.

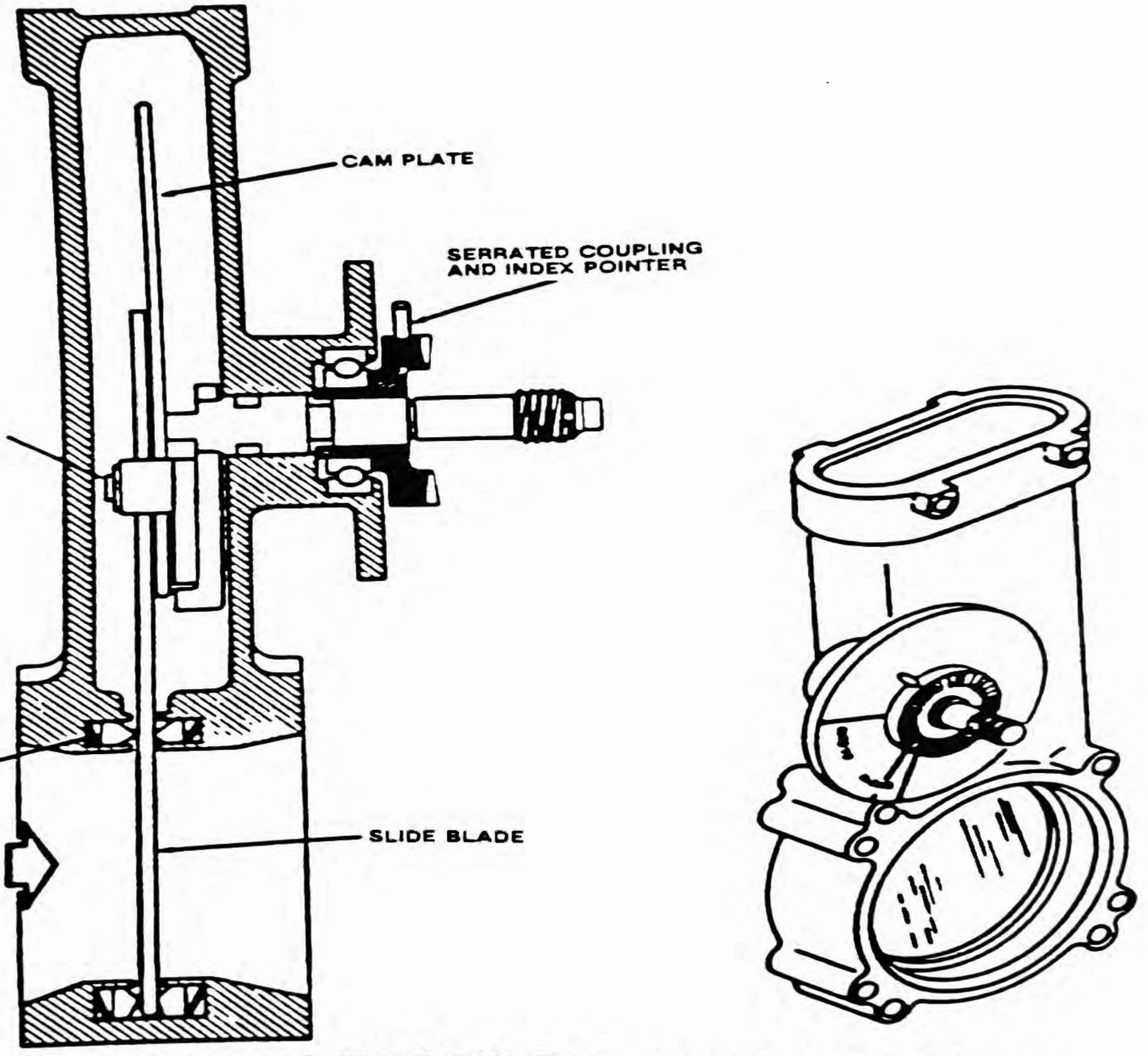
(b) The engine hydraulic fire shutoff valve is mounted on a 2-piece channel bracket which is installed inside the wing leading edge, aft of the firewall of each inboard pylon. Access to the valve is through the access door located on the lower side of the wing leading edge, outboard of either the left or right inboard pylon. Each valve is located approximately 30 inches inboard of the access door.

(c) Internally, the valve consists of a valve arm, valve arm link, cam plate, and slide blade. The valve arm link attaches to the valve arm and is allowed to swivel through an arc in relation to the valve arm. The link has a stop that will contact the arm when the two have traveled to the valve closed, full overtravel position. In the full open pretravel position, the link contacts the arm stop.

(d) A roller attached to the end of the link rides in, and extends through, a J-shaped slot in the cam plate. The rotation of the valve arm causes the link roller to follow the cam slot, allowing the arm and link to move through independent arcs.

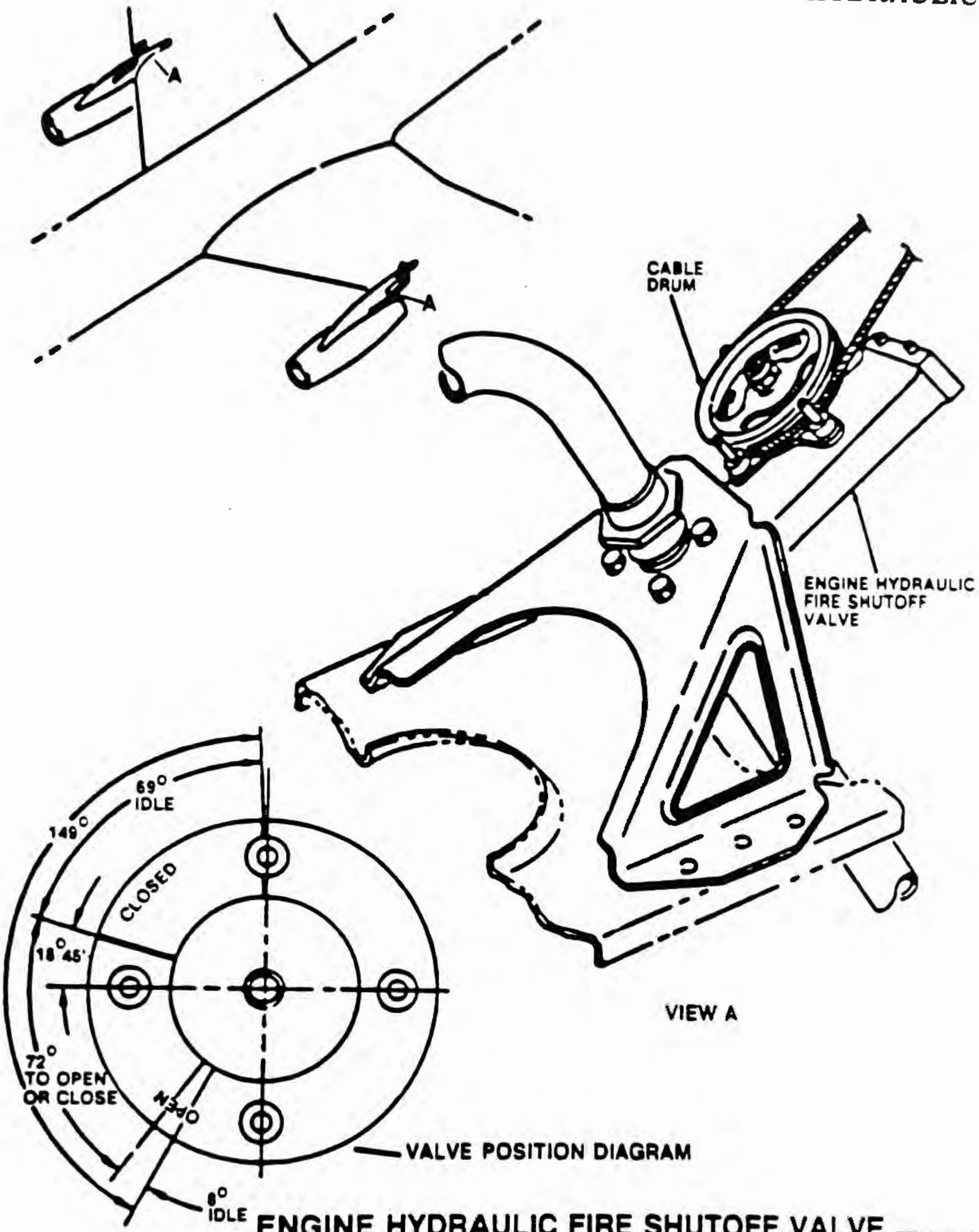
(e) The slide blade (gate of the valve) is slotted near the one end and also receives the link roller extending through the cam slot. The slide blade is positioned parallel to the cam plate and is guided by two grooves in the housing. This will allow the blade to open or close through porting of the valve by the action of the arm and link. The cam plate is pinned to the valve shaft, securing it rigidly in two positioning grooves in the housing. A pin-indicator is provided to relate valve position to a reference plate placarded open and closed.

(f) The engine hydraulic fire shutoff valves are cable actuated by the fire control handles, located on the overhead switch panel in the flight compartment. When the fire control handle for either inboard engine is moved, the cable system rotates the drum which is attached to the corresponding shutoff valve shaft. This action extends the valve blade into the fluid passage to block the flow of fluid. The valve operates from open to close by clockwise rotation of the cable drum. The valve gage will idle during the first 8 degrees of rotation of the cable drum, and then will close in the next 72 degrees. The cable drum will continue to rotate the shaft for an additional 69 degrees after the gate valve is closed, locking it overcenter. Total travel of the cable drum is 149 degrees.



ENGINE HYDRAULIC FIRE SHUTOFF VALVE SCHEMATIC

Figure 29-13



ENGINE HYDRAULIC FIRE SHUTOFF VALVE FTX80072

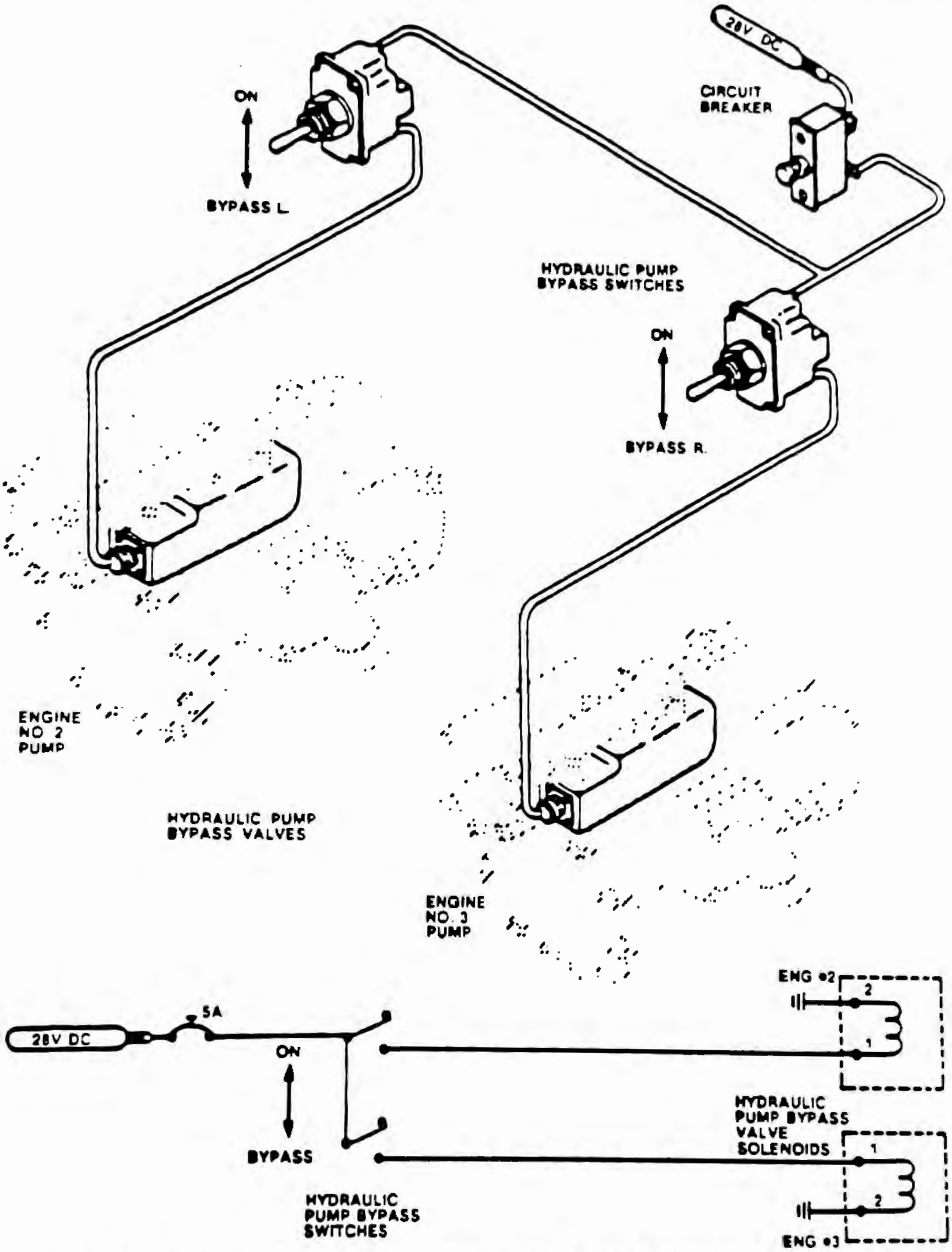
Figure 29-14

(10) Engine-Driven Hydraulic Pump (See Figures 29-15, 29-16 & 29-17)

(a) A variable-displacement, pressure-compensated, engine-driven hydraulic pump is installed on each inboard engine. Each pump incorporates a solenoid-operated bypass feature for reducing the output of the pump. the bypass valves are controlled by two engine hydraulic pump switches in the flight compartment. The switch for the hydraulic pump on engine no. 2 is placarded L/LEFT, ON and BYPASS. The switch for the hydraulic pump on engine no. 3 is placarded R/RIGHT, ON and BYPASS. When either of the two engine hydraulic pump control switches is placed in the BYPASS position, the bypass valve solenoid for that hydraulic pump is energized and the pump pressure decreases to 700 psi. Fluid pressure is blocked from entering the pressure port by the pump outlet blocking valve. When either switch is in the ON position, the control circuit to the corresponding bypass valve is open and the hydraulic pump operates normally in the pressure range of 2850-3000 psi. Each pump provides a continuous, non-pulsating flow of hydraulic fluid, under pressure, to the hydraulic manifolds for distribution throughout the hydraulic system. Each of the engine-driven pumps is located on the accessory drive pad of the inboard engine. These pumps are accessible through the access doors on the right side of the nacelles.

(b) Hydraulic fluid enters the pump via the inlet port (33) of the valve plate and controls subassembly (8). Internal passages direct this flow to the inlet side of cylinder block (4) which is splined to and driven in rotation by a drive shaft (7).

(c) The yoke (6) swivels on two pintle bearings (11). The yoke is normally held at a maximum angle of displacement with relation to the drive shaft axis by action of a control spring (13). In this position, pistons reciprocate in the cylinder block bores drawing fluid in on the inlet side of the valve plate and cylinder block and forcing it out through the outlet port (34). Each of the pistons completes this cycle during each revolution of the drive shaft. This provides a continuous, non-pulsating flow of fluid to the hydraulic system.


28V DC
CIRCUIT BREAKER
ON
BYPASS L
HYDRAULIC PUMP BYPASS SWITCHES
ON
BYPASS R
ENGINE NO 2 PUMP
HYDRAULIC PUMP BYPASS VALVES
ENGINE NO. 3 PUMP
28V DC
5A
ON
BYPASS
HYDRAULIC PUMP BYPASS SWITCHES
ENG #2
2
1
HYDRAULIC PUMP BYPASS VALVE SOLENOIDS
1
2
ENG #3

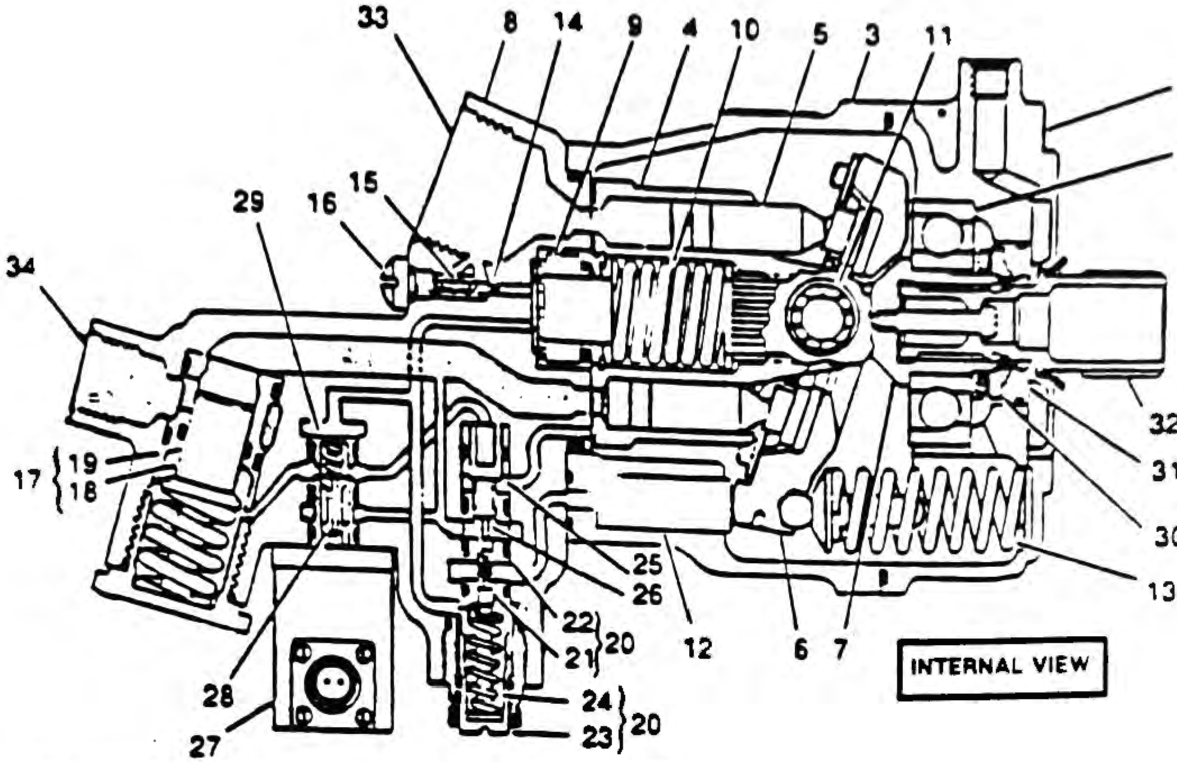
ENGINE HYDRAULIC PUMP BYPASS VALVE CONTROL FTX80075

Figure 29-15

(d) Resistance to fluid flow in the hydraulic circuit causes pressure to build up at the outlet port of the pump. The greater this resistance to flow, the greater the pressure build-up. Pressure rise is reflected through pressure sensing passages in the valve plate and acts on the pressure compensator valve (20). As system pressure exceeds a predetermined maximum established on test by the adjustment of the adjusting screw (23), hydraulic pressure, acting on pilot valve (21), overcomes the force of spring (24), and allows a metered quantity of oil to flow to the actuator piston (12). Under these conditions, pressure oil overcomes the force of the control spring (13), and forces the actuator piston to move the yoke toward a minimum angle of displacement resulting in a stoppage of outlet flow. As system pressure drops below this no flow position, the force of the control spring (13), overcomes hydraulic pressure to force the yoke to move toward a maximum angle of displacement.

(e) Manual control of pump output is provided by the solenoid-operated bypass (depressurizing) valve (27). When this valve is activated, hydraulic fluid is directed to the control piston (25), which together with the control valve (26) positions the pilot valve (21) to direct outlet pressure to the actuator piston (12). From here on, the operation is the same as that previously described for operation of the pressure compensator valve (20) except that the pressure required is greatly reduced. When depressurized, pump outlet flow is reduced to zero, and the pump will develop whatever internal pressure is required to stroke the yoke to near zero position. This pressure is approximately 700 psig. In addition, fluid generated for internal pump operation is approximately 1.0 gpm which provides lubrication and cooling flow for pump components. This flow is discharged through the case drain port. In the depressurized mode of operation, the load on the pump and the power required to drive the pump is greatly reduced.

(f) The outlet blocking valve (17) is used in conjunction with the bypass (EDV) valve to block flow from the outlet port of the pump. When the bypass valve solenoid is energized, outlet pressure is directed to the spring side of the blocking valve plunger, closing the valve.

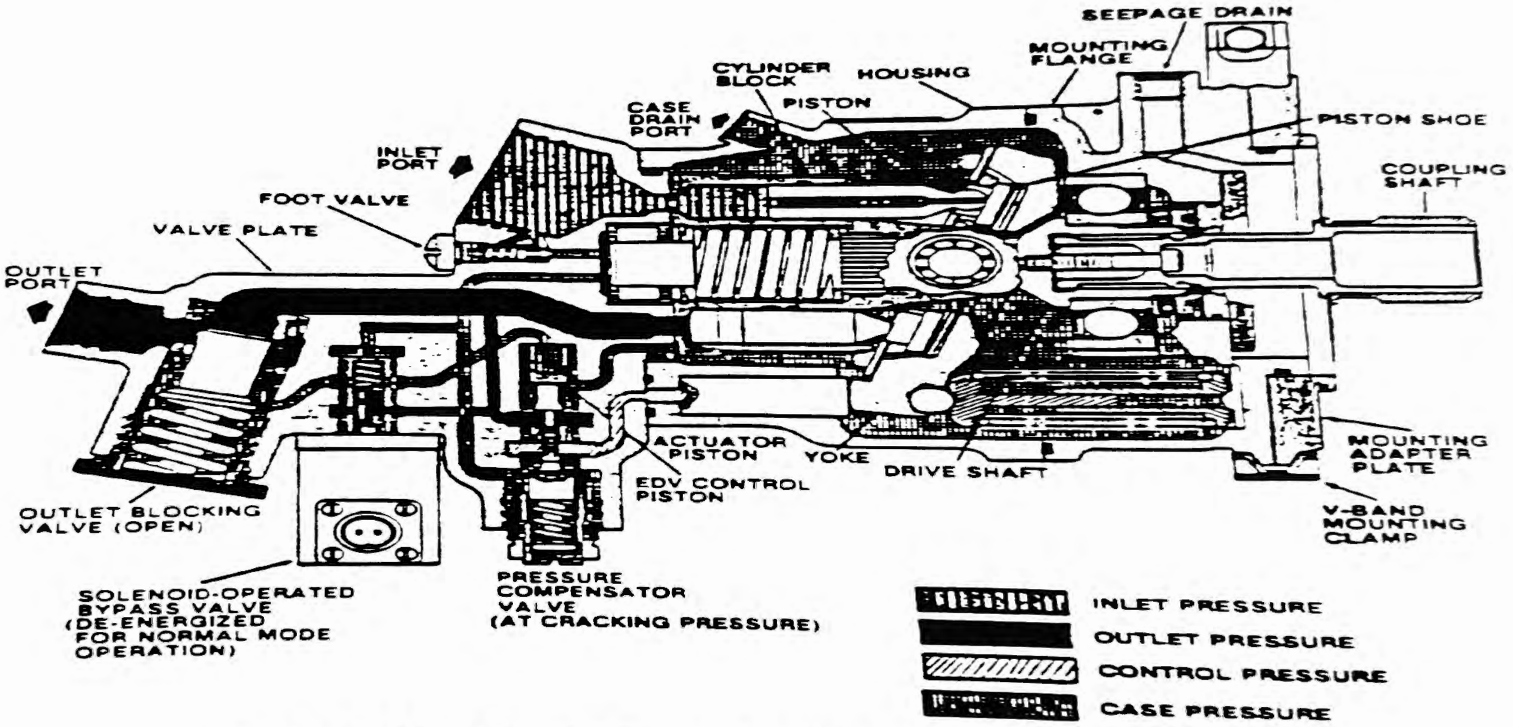


1. MOUNTING FLANGE
2. DRIVE SHAFT BEARING
3. HOUSING
4. CYLINDER BLOCK
5. PISTON AND SHOE SUBASSEMBLY
6. YOKE
7. DRIVE SHAFT
8. VALVE PLATE AND CONTROLS SUBASSEMBLY
9. ROLLER BEARING SPRING
10. CYLINDER BLOCK SPRING
11. PINTLE BEARING
12. ACTUATOR PISTON
13. CONTROL SPRING
14. FOOT VALVE
15. SPRING
16. FOOT VALVE SCREW
17. OUTLET BLOCKING VALVE
18. PLUNGER
19. SEAT
20. PRESSURE COMPENSATOR VALVE
21. PILOT VALVE
22. BUSHING
23. ADJUSTING SCREW
24. SPRING
25. CONTROL PISTON
26. CONTROL VALVE
27. SOLENOID-OPERATED BYPASS (EDV) VALVE
28. SLIDE VALVE
29. BUSHING
30. SHAFT SEAL SUBASSEMBLY
31. MATING RING
32. COUPLING SHAFT
33. INLET PORT
34. OUTLET PORT

VARIABLE DISPLACEMENT HYDRAULIC PUMP ASSEMBLY

FTX80506

Figure 29-16



ENGINE-DRIVEN HYDRAULIC PUMP PRESSURE FLOW

FTX80507

Figure 29-17

(11) Engine-Driven Hydraulic Pump Check Valves (See Figure 29-18)

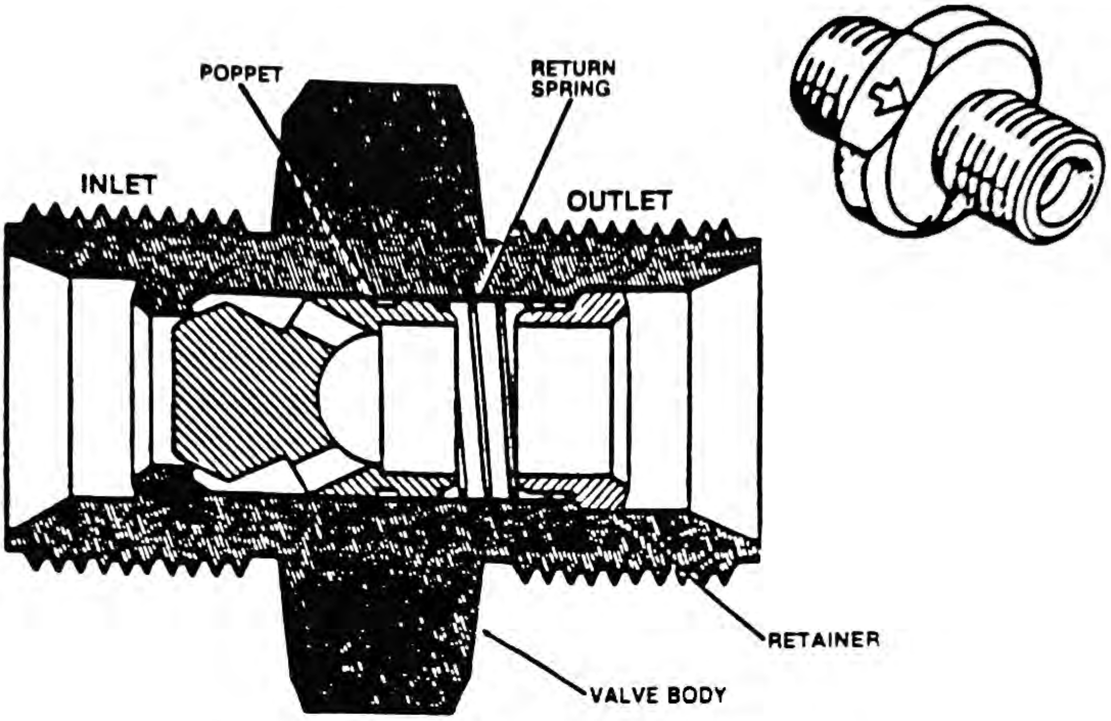
(a) Two check valves, rated at 3000 psi, are installed in the lines from each engine-driven hydraulic pump. One check valve is installed in the pressure line and the other is in the case drain line. The check valves in the pump pressure lines prevent reverse flow of hydraulic fluid through the pump, when the pump is inoperative or when external hydraulic pressure is supplied to the system. Access to the valves can be gained through an access door in the forward right apron of each inboard pylon. The valves are mounted on the exterior wall of the inlet box by means of the bulkhead fittings and retaining nuts.

(b) Normal operating pressure will unseat the poppet, and fluid will flow through the valve. When pressure downstream of the valve exceeds pressure from the pump, the pressure, with the aid of the return spring, will seat the poppet. This prevents reverse flow of hydraulic fluid through the pumps.

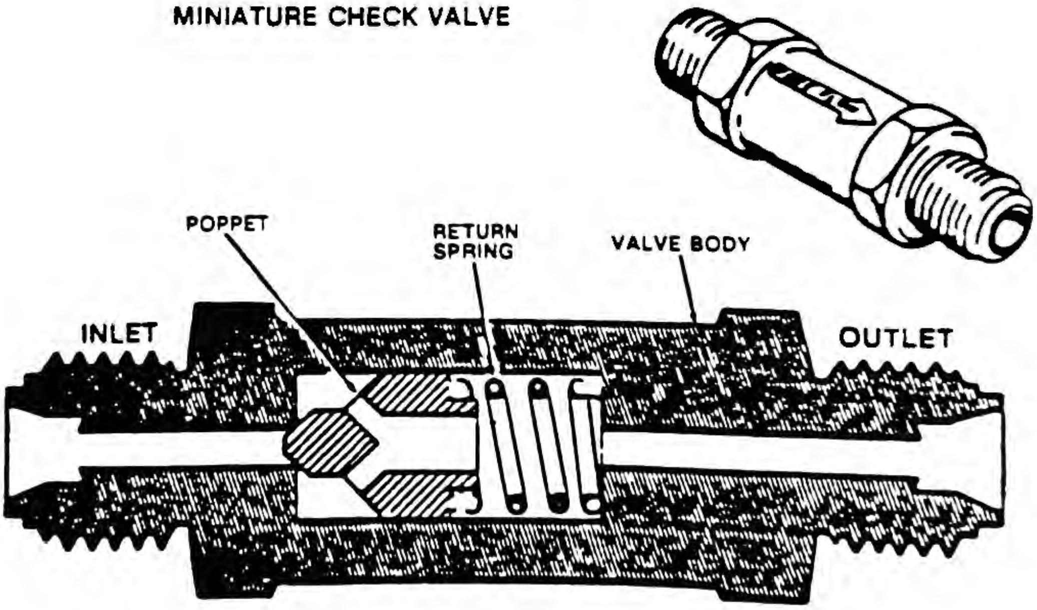
(12) Engine-Driven Hydraulic Pump Case Drain Filter (See Figure 29-19)

(a) A line-type, micronic filter, for use in a low-pressure hydraulic system, is installed in the engine-driven hydraulic pump case drain return line between the pump flow check valve and the hydraulic system reservoir. The case drain filter is installed on the aft surface of the rear spar opposite the leading edge of the inboard flap assembly. One filter is used for each engine-driven pump. Access is gained to the filter by lowering the flaps. A second check valve is installed adjacent to the filter in the downstream side of the case drain return line.

(b) Externally, the filter is approximately 5 inches high and 2 inches wide, with ports marked inlet and outlet. The bowl is cylindrical in shape, with hex-shaped wrench flats at the lower end. A self-sealing, magnetic drain plug is installed in the bottom end of the filter bowl. The filter element is made of chemically treated paper.



MINIATURE CHECK VALVE

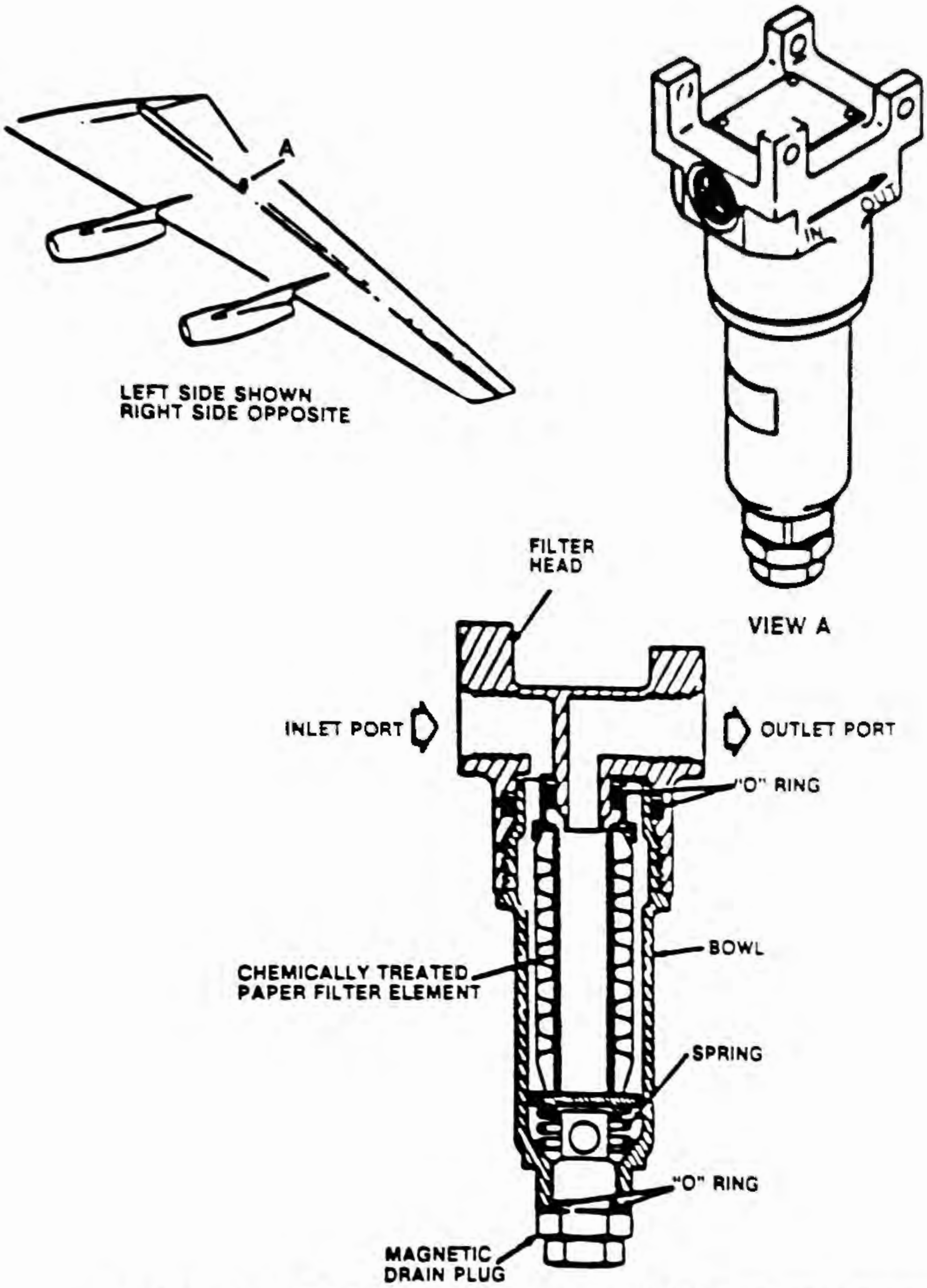


STANDARD CHECK VALVE

HYDRAULIC CHECK VALVES - TYPICAL

FTX80070

Figure 29-18



ENGINE DRIVEN HYDRAULIC PUMP CASE DRAIN FILTER - CUTAWAY VIEW

FTX80076

Figure 29-19

(13) Dual Filter and Relief Valve (See Figure 29-20)

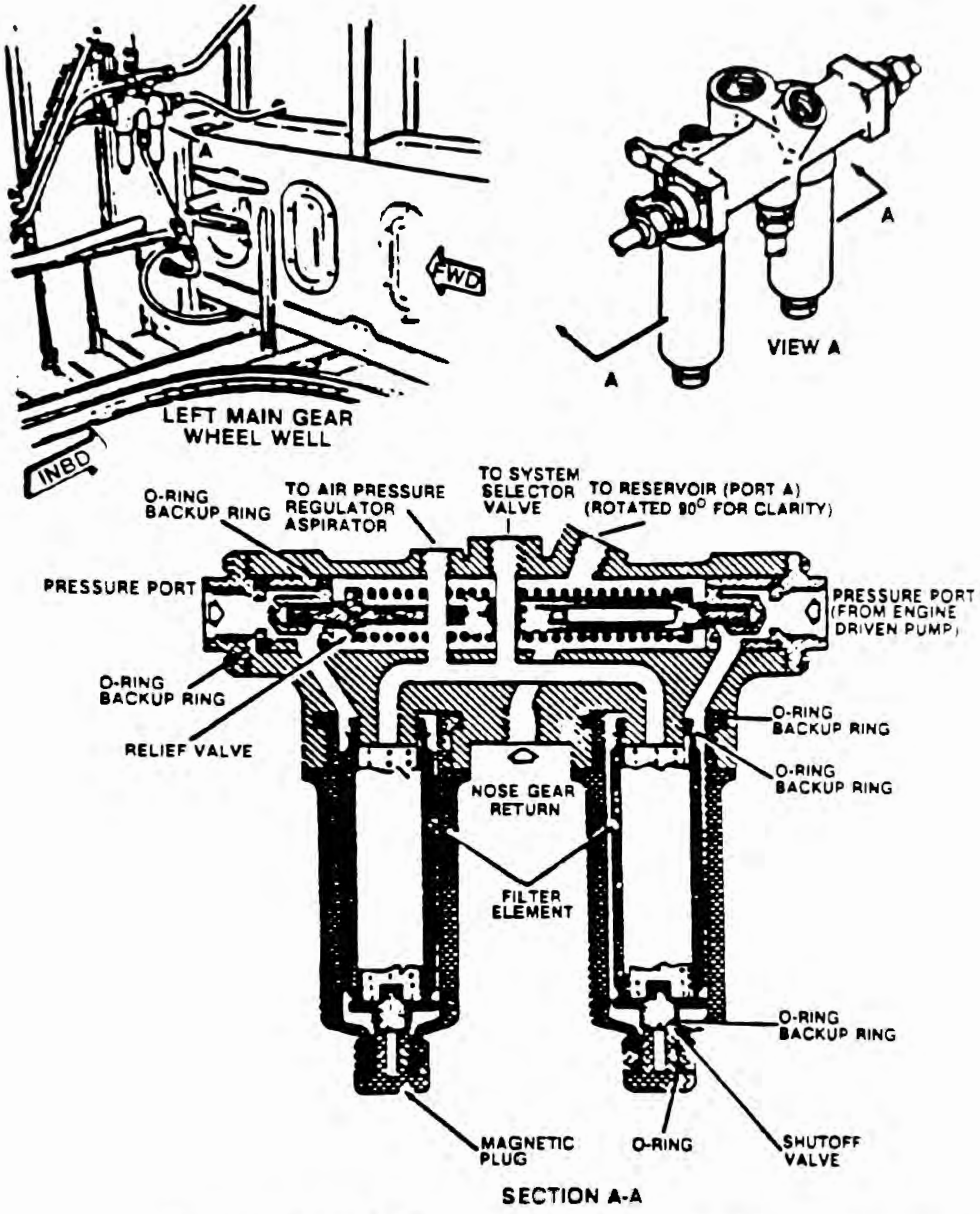
(a) The hydraulic power system dual filter and relief valve consists of two filters and two relief valves installed in the same body. The unit filters the hydraulic fluid from the two engine-driven hydraulic pumps, and the pressure relief valves assure that excessive pressures do not build up in the pressure line from the pumps. The unit is located in the left main gear wheel well on the lower portion of the rear spar, approximately 1 foot outboard of the centerline shear web.

(b) The unit consists of a casting with a flange-mounted pressure inlet port on each end. Two pressure outlets are located on the top of the casting. One outlet, centrally located, is the main pressure outlet to the system selector valve. The other, located to the left of the selector valve port, is the pressure outlet to the air pressure regulator-aspirator. The return outlet port for the relief valve portion of the unit is located on the center of the aft face of the body, canted upward. The nose gear return line is connected to a check valve installed in a return line port, located between the two filter bowls.

(c) The pressure relief valves are located behind the pressure inlet ports and are connected to the return outlet port of the unit. The inlet from the nose gear return line is routed through the casting to the return outlet port.

(d) If either of the filter elements becomes clogged, pressure above 3300 psi at the inlet port will unseat the poppet. Pressure above 3500 psi will allow full flow of 22.5 gpm to flow to the return port of the unit and back to the reservoir. The relief valves will reseat at approximately 3000 psi.

(e) A check valve is installed in the system selector valve port to prevent reverse flow of pressure through the filter during auxiliary hydraulic pump operation.



DUAL-FILTER AND RELIEF VALVE - CUTAWAY VALVE

FTX80077

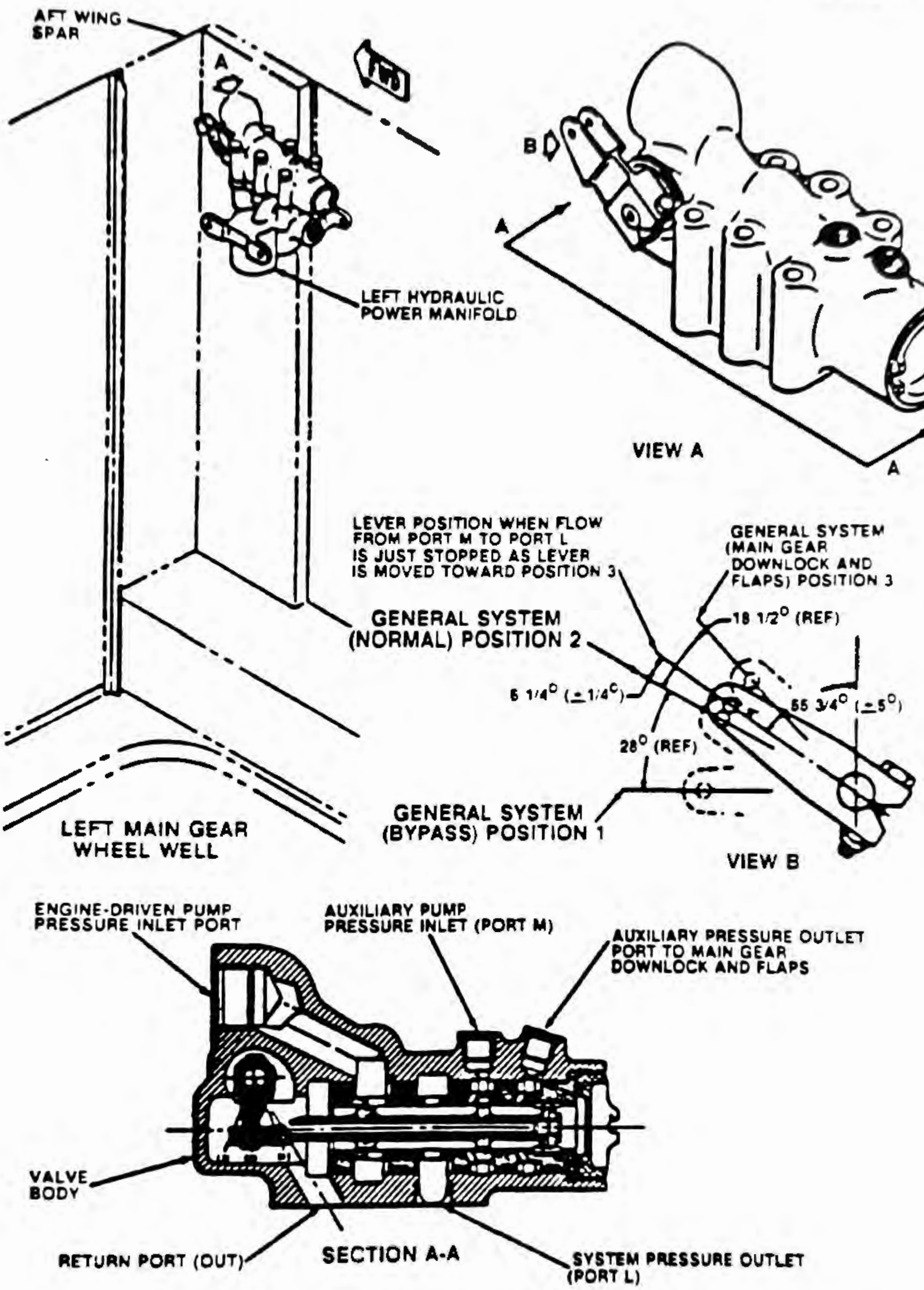
Figure 29-20

(14) System Selector Valve (See Figures 29-21 & 29-22)

(a) The system selector valve is a 3-position valve which permits directional control of fluid under pressure. The valve is installed on the left hydraulic power manifold and is accessible through the left main gear inboard door.

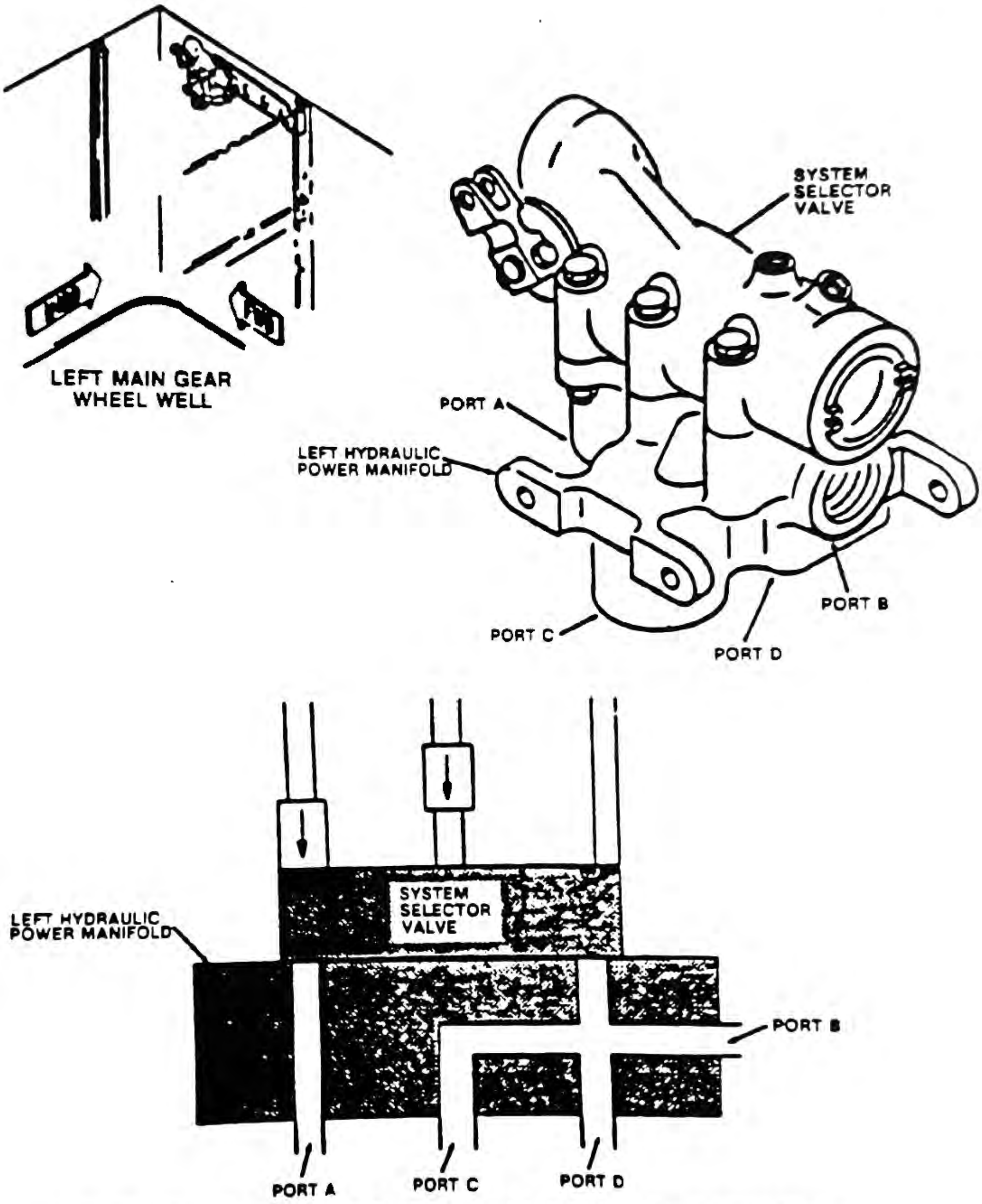
(b) The selector valve pressure-to-system port and the return port are directly ported to the manifold. The engine pump pressure enters the valve through a port on the large end of the valve, and the auxiliary pump inlet and alternate ports are located at the top, toward the aft end of the valve. The valve control crank is attached to a push-pull rod and a cable sector.

(c) Operation of the system selector valve is controlled by a lever located on the right side of the system engineer's control pedestal. When the control lever is moved to the selected position, the cable system, through the sector and crank, operates the valve positioning lever to drive the slide spool assembly to the selected position. When the control lever is placed in the general system (normal) position, the selector valve is actuated, causing hydraulic fluid to enter the valve through the system pressure port. The fluid is then directed into the manifold through the pressure-to-system port. In the general system (normal) position, fluid from the auxiliary pressure port is also routed to the pressure-to-system port. In the bypass/general system position, the selector valve ports engine pump pressure into the manifold through the return port. In this position, the auxiliary pump pressure is ported to the general system. In the general system/main gear down and flaps position, pump pressure is routed through the alternate port, at the top of the valve, for alternate operation of the flaps and the landing gear downlock cylinders. Internal leakage provides lubrication for the moving parts of the valve.


AFT WING SPAR
A
FWD
B
A
LEFT HYDRAULIC POWER MANIFOLD
VIEW A
A
LEVER POSITION WHEN FLOW FROM PORT M TO PORT L IS JUST STOPPED AS LEVER IS MOVED TOWARD POSITION 3
GENERAL SYSTEM (MAIN GEAR DOWNLOCK AND FLAPS) POSITION 3
18 1/2° (REF)
GENERAL SYSTEM (NORMAL) POSITION 2
6 1/4° (±1/4°)
55 3/4° (±5°)
28° (REF)
GENERAL SYSTEM (BYPASS) POSITION 1
VIEW B
LEFT MAIN GEAR WHEEL WELL
ENGINE-DRIVEN PUMP PRESSURE INLET PORT
AUXILIARY PUMP PRESSURE INLET (PORT M)
AUXILIARY PRESSURE OUTLET PORT TO MAIN GEAR DOWNLOCK AND FLAPS
VALVE BODY
RETURN PORT (OUT)
SECTION A-A
SYSTEM PRESSURE OUTLET (PORT L)

SYSTEM SELECTOR VALVE CUTAWAY VIEW FTX80079

Figure 29-21



LEFT HYDRAULIC POWER MANIFOLD SCHEMATIC

FTX80080

Figure 29-22

(15) Left Hydraulic Power Manifold (See Figure 29-22)

(a) The left hydraulic power manifold distributes fluid pressure from the hydraulic pump (any one of the three pumps), through control valves to the various airplane hydraulic subsystems. The left power manifold is located overhead in the left wheel well. Access to the left manifold is through the left main gear inboard door.

(b) One valve-mounting pad is provided on the top of the manifold for the system selector valve. Four ports are provided on the manifold for connection of hydraulic pressure and return lines. Three of these ports are pressure outlet ports; one, located on the aft face of the manifold and one located on the bottom of the manifold port fluid to the flight controls. The third pressure outlet port, located on the bottom of the manifold, ports fluid directly to the priority valve, which in turn, ports fluid to the nose gear and to the right power manifold. The fourth, a return port, located immediately forward of the pressure line port on the bottom of the manifold, is connected by a line to a return port of the reservoir.

(16) Right Hydraulic Power Manifold (See Figure 29-23)

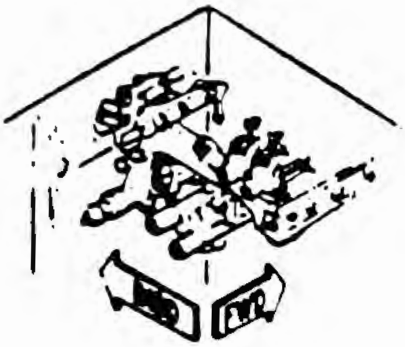
(a) The right hydraulic power manifold distributes fluid pressure from the hydraulic pumps (engine-driven or auxiliary, or any combination of these three pumps), through the control valves to the various hydraulic subsystems. The right hydraulic power manifold is located overhead in the right wheel well. The manifold is held in place with braces and is accessible through the right main gear inboard door.

(b) The manifold contains passages for pressure and return fluid distribution, four check valves, ports for pressure and return lines, and mounting pads for the various control valves.

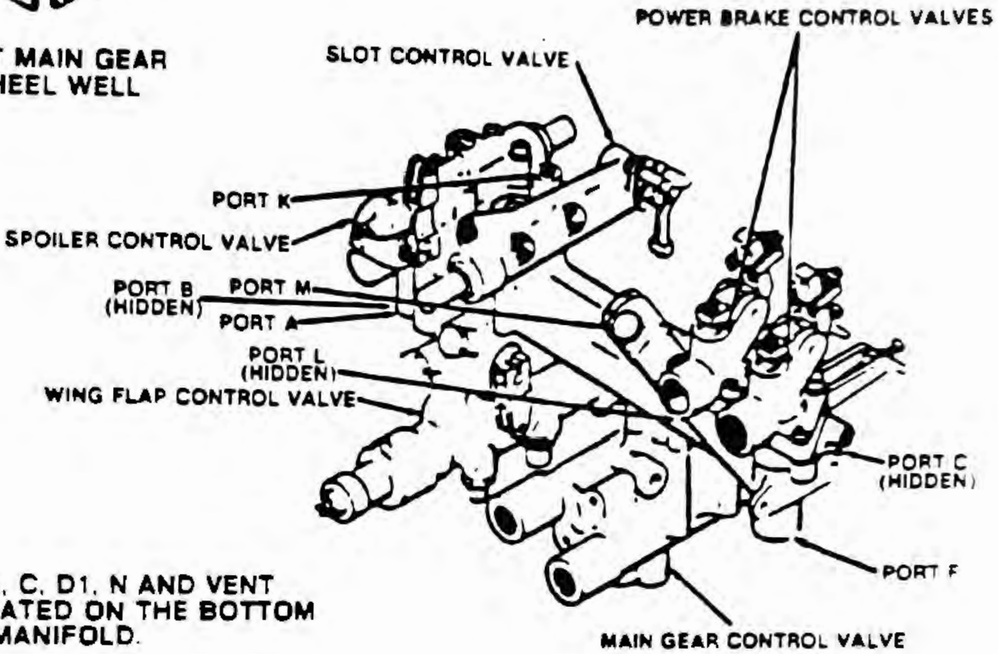
(c) The right manifold receives fluid pressure from the left manifold. Pressure is ported through check valves to the wing flap control valve, to the slot control valve, to the main gear control valve, to the brake control valve, to the brake pressure transmitter, and to the brake accumulators.

(d) Auxiliary hydraulic pressure is ported from the alternate port of the system selector control valve into port K in the right manifold. Port K is located inboard of the spoiler control valve. From port K, auxiliary hydraulic pressure is ported through a check valve to the downstream side of the wing flap control valve check valve and into the wing flap control valve for alternate operation of the wing flaps.

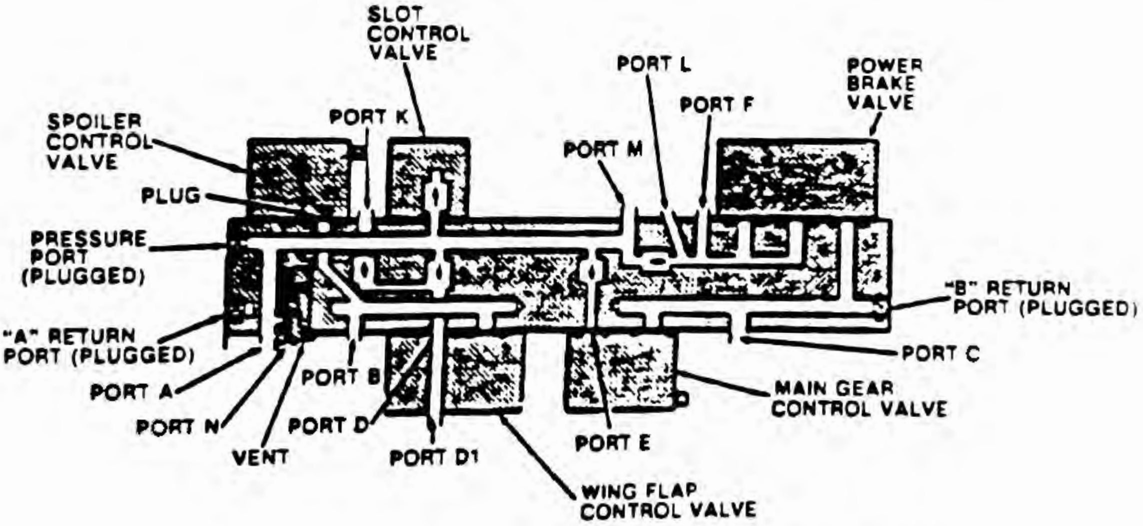
(e) The return passage from the wing flap control valve ports fluid to return port A. The brake control valve return passage ports fluid into return line B through a two-way restrictor. The main gear control valve downline return fluid uses a separate port in the valve, bypasses the manifold, and returns the fluid directly to A return line to the reservoir. The upline in the main gear control valve uses the same return port, return port B, in the manifold as the brake control valve.



RIGHT MAIN GEAR WHEEL WELL



NOTE: PORTS B, C, D1, N AND VENT ARE LOCATED ON THE BOTTOM OF THE MANIFOLD.



RIGHT HYDRAULIC POWER MANIFOLD SCHEMATIC

FTX80081

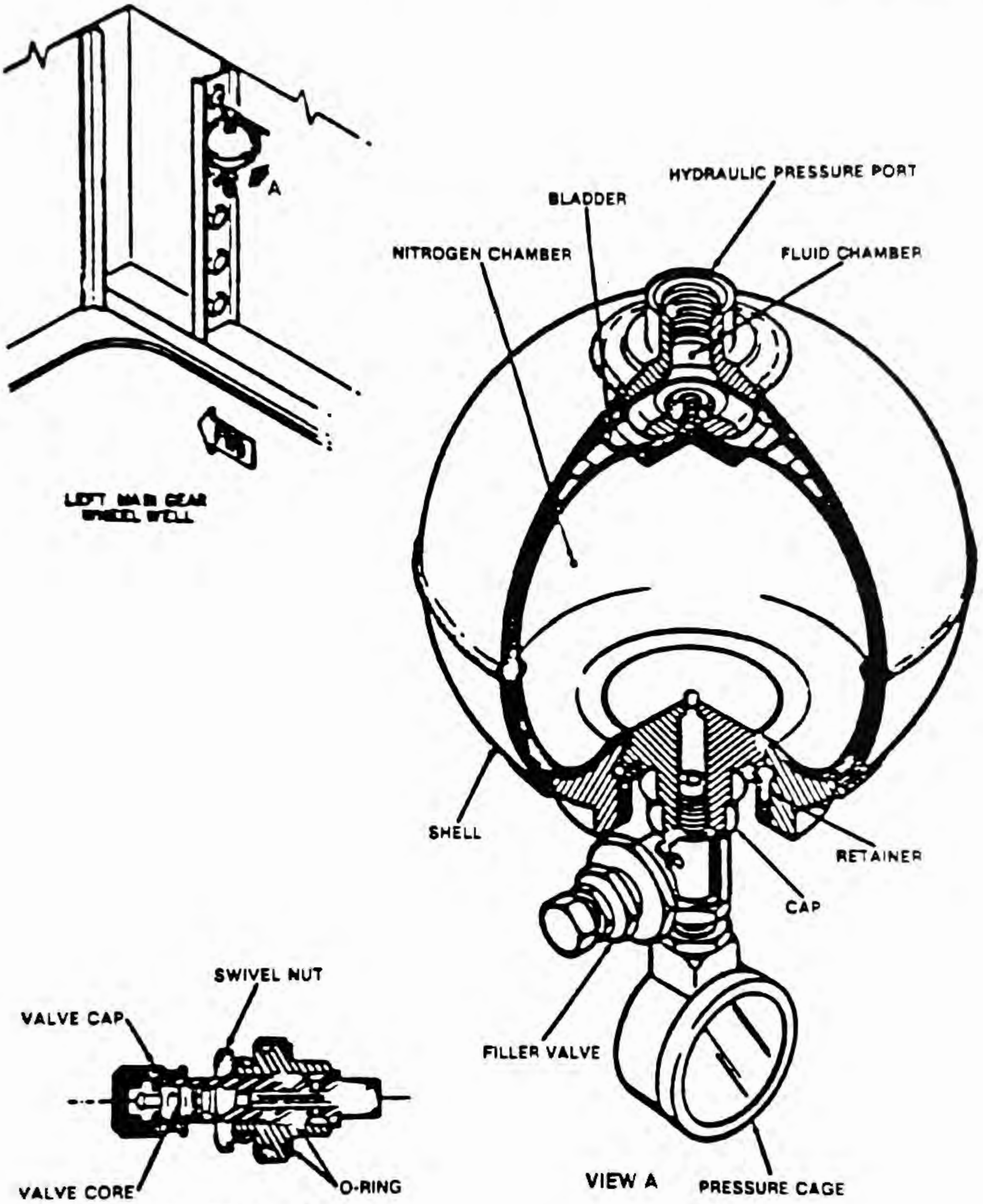
Figure 29-23

(17) Hydraulic Power System Accumulator (See Figure 29-24)

(a) The hydraulic power system accumulator is spherical, welded-steel, fluid and air bladder-separated container. The accumulator is installed in the pressure line of the hydraulic power system to provide a reserve supply of fluid under pneumatic pressure and to act as a shock absorber for system pressure surges.

(b) The accumulator is located immediately aft of the left hydraulic power manifold and is accessible through the left main gear inboard door. It is mounted with two corner brackets and clamp blocks at the upper and lower port fittings.

(c) The accumulator is installed in the pressure line of the hydraulic power system and is initially charged with 1000 psi of dry nitrogen. As the system pressure builds up, fluid is forced into the upper chamber of the accumulator, further compressing the trapped nitrogen to approximately 3000 psi. With full hydraulic system pressure, 3000 psi is indicated on the pressure gage adjacent to the filler valve. This reserve pressure smooths out any momentary lag in the pump's response to the system's demands for greater fluid flows. The accumulator permits gradual rise in system pressure, thereby absorbing the shock of pump surges and relieving the piping and system operating units of high-impact loads. When the engine-driven hydraulic pumps are not operating, the accumulator provides system pressure (at a diminishing rate) until a quantity equal to the stored volume in the accumulator has been used by the system.



HYDRAULIC POWER SYSTEM ACCUMULATOR CUTAWAY VIEW

FTX80082

Figure 29-24

(18) Hydraulic System Priority Valve (See Figure 29-25)

(a) The priority valve is located in the left wheel well near the left hydraulic power manifold. The valve is installed in the hydraulic pressure line, between the two power manifolds, downstream of the pressure supply takeoff port for the flight controls. The priority valve is a balanced relief valve which reserves initial hydraulic pressure (up to 2150 psi maximum) for use in the flight control systems. The valve consists of a body with an inlet, an outlet, and a breather port. Internally, the valve contains a poppet valve plate, a poppet, a poppet valve load-spring, a piston, a piston load-spring, and a piston load-spring housing. The piston load-spring housing chamber is vented to ambient air through a breather hole which is covered by a butyl rubber band.

(b) The priority valve shuts off hydraulic pressure to all subsystems downstream of the left power manifold, whenever the hydraulic pressure drops below 1700 psi minimum. At this point, the valve closes to reserve the hydraulic pressure for use in the flight control systems, preventing them from reverting to manual operation. When the hydraulic pressure rises to 2150 psi maximum, the priority valve opens and supplies pressure to the right manifold and all subsystems downstream of the priority valve.

(c) Hydraulic fluid from the left power manifold enters the priority valve through the inlet port, passes through the poppet valve plate holes, and applies pressure against the piston. When sufficient hydraulic pressure is applied to the piston, the piston load-spring compresses, unseating the poppet and permitting full flow through the valve. When the hydraulic pressure decreases to less than the opposing force value of the piston load-spring, the load-spring forces the piston against the poppet and shuts off fluid flow through the valve.

(d) The maximum flow available from both engine-driven hydraulic pumps is: 44 to 45 gpm at takeoff, climb, and cruise configurations; 26 to 28 gpm at descent, approach, and engine idle configurations.

(e) Some of the larger hydraulic system demands are as follows:

1 Gear retraction - 17 gpm (10-12 seconds)

2 Gear extension - 14 gpm (10-12 seconds)

3 Wing flaps down - 8 gpm (10 seconds)

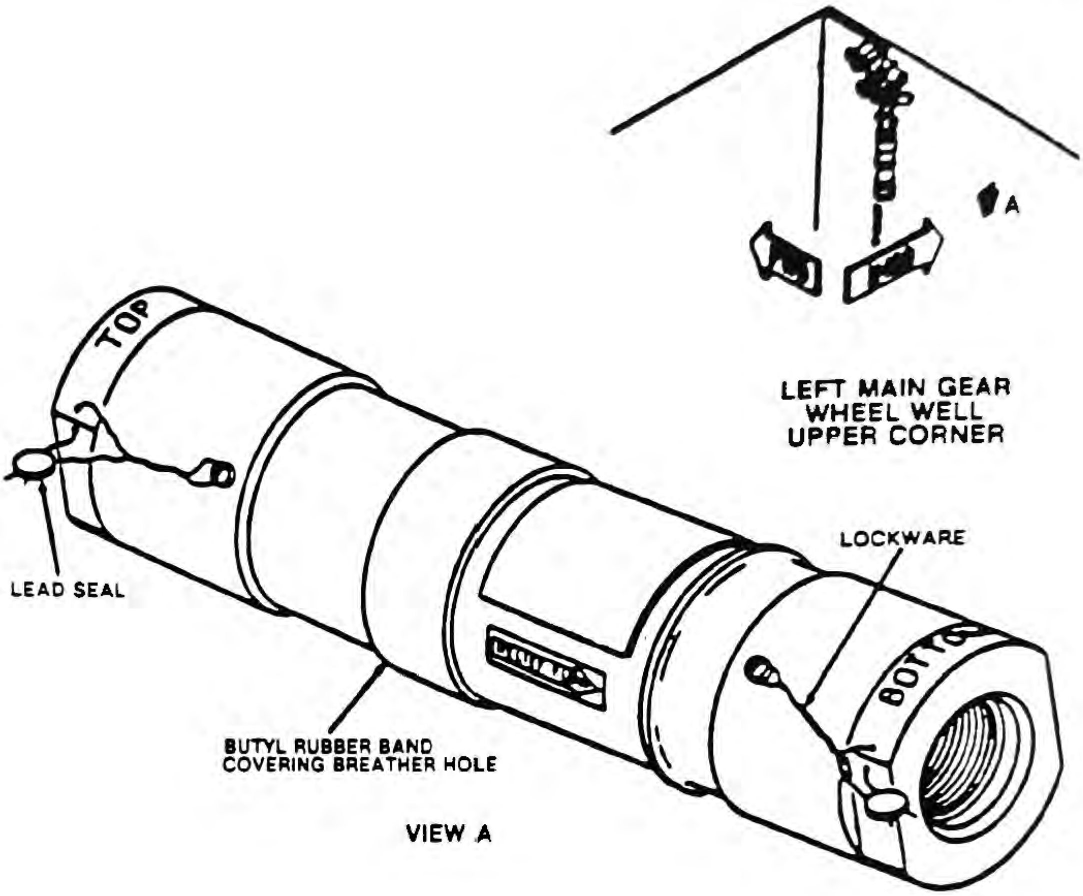
4 Wing flaps up - 3 gpm (22 seconds)

5 Horizontal stabilizer - 7 gpm

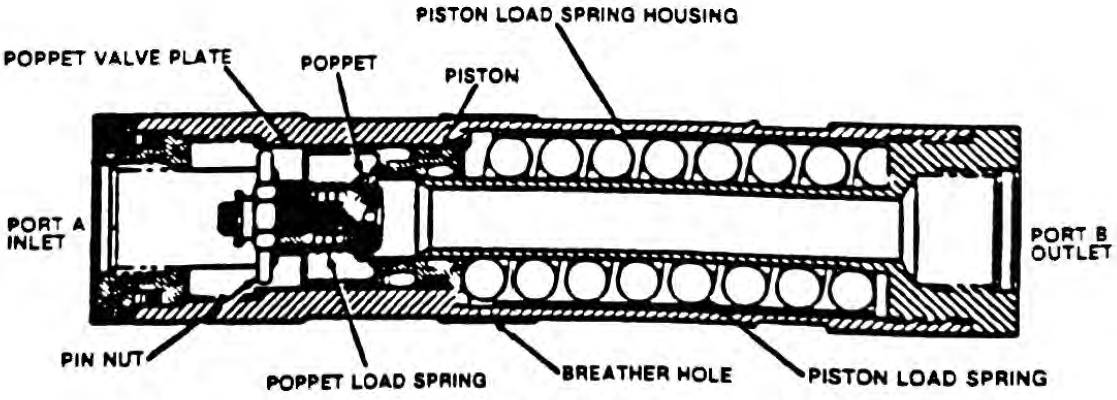
6 Ailerons - 17 gpm (25°/second)

7 Rudder - 3 gpm (25°/second)

(f) There are various combinations of hydraulic system operations which could cause momentary reversion of the flight controls to manual operation. To prevent reversion to manual operation the priority valve assures that the left power manifold receives all the hydraulic fluid pressure under conditions of very large flow demands.


A
LEFT MAIN GEAR WHEEL WELL UPPER CORNER
TOP
LEAD SEAL
LOCKWARE
BOTTOM
BUTYL RUBBER BAND COVERING BREATHER HOLE

VIEW A



HYDRAULIC SYSTEM PRIORITY VALVE CUTAWAY VIEW

FTX80083

Figure 29-25

(19) Manual Shutoff Valve (See Figure 29-26)

(a) On some aircraft, two manually operated shutoff valves are provided just downstream of the priority valve for isolation of non-priority subsystems during maintenance operations. One valve shuts off pressure to the following subsystems:

1 Wing flaps

2 Wing slots

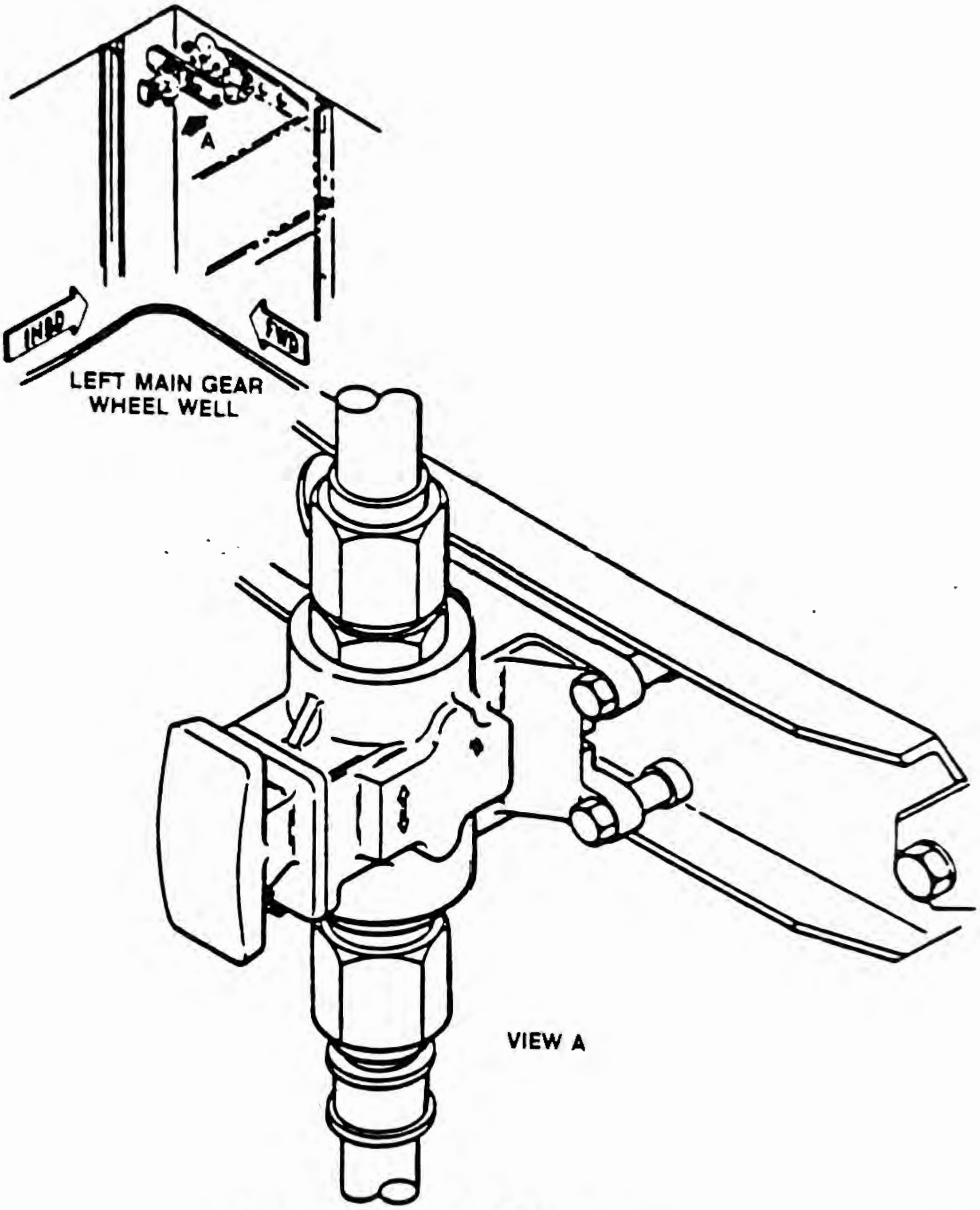
3 Main landing gear retraction

4 Power wheel brakes

(b) The other valve shuts off pressure to the nosegear retraction and nosewheel steering subsystems.

(c) The manual shutoff valves are located in the upper inboard forward corner of the left main gear wheel well. One valve is mounted on the left power manifold support, the other is mounted to a structure stiffener.

(d) The valves consist of two position (on-off), rotary type, valves with identical and interchangeable inlet and outlet ports. A T-shaped handle is provided on each valve for manual operation and lockwire holes are provided in the base of the handle for safetying the vale in the open position.



MANUAL SHUTOFF VALVE

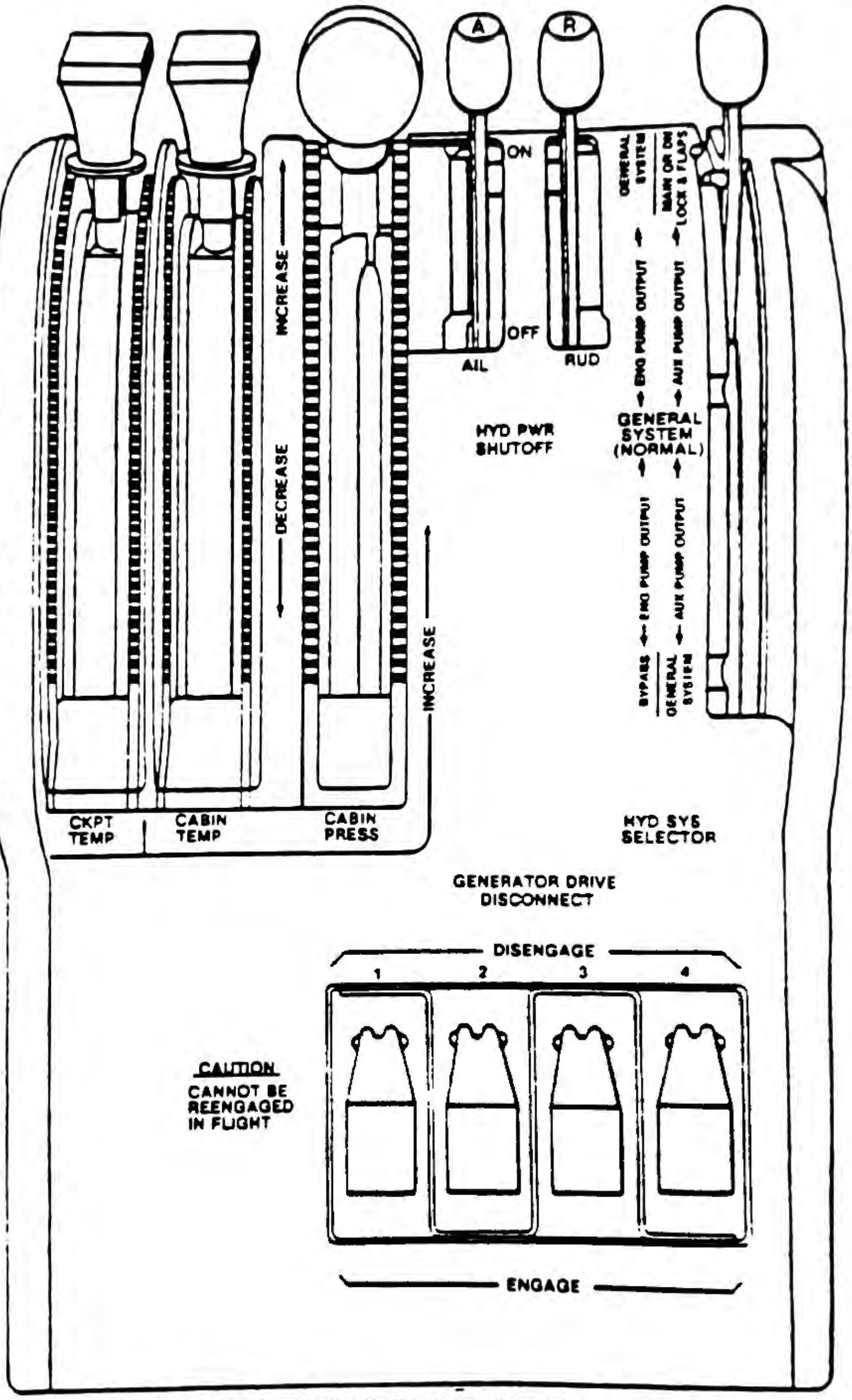
FTX80064

Figure 29-26

(20) Hydraulic System Selector Control Lever (See Figure 29-27 & 29-28)

(a) The hydraulic system selector control lever is manually actuated, mechanical lever detented to three positions. The lever provides a mechanical means, through cables, for positioning the system selector valve and the auxiliary hydraulic pump supply selector valve. The hydraulic system selector control lever is located on the system engineer's control pedestal. The lever is attached to a driver sector, located on a common shaft with the other control pedestal sectors. The lever and sector and accessible through the cover plates on the system engineer's pedestal.

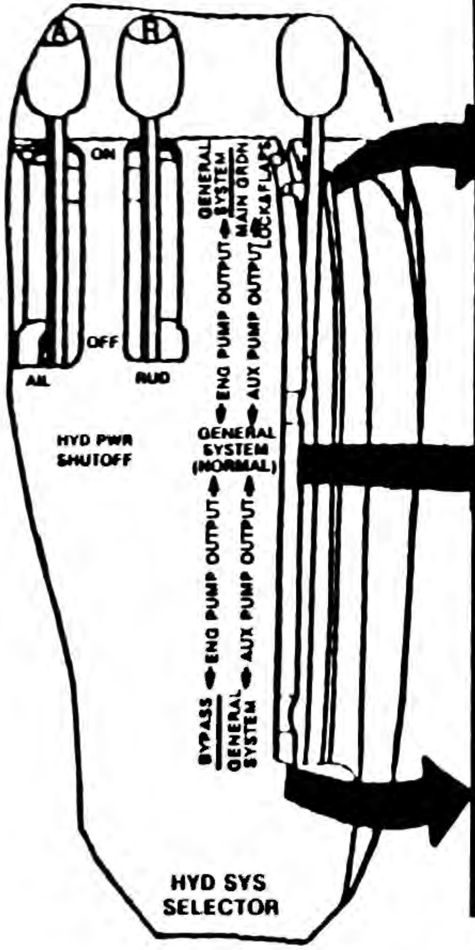
(b) To put the hydraulic power system in the bypass condition, the system selector control lever is lifted out of detent and moved to bypass/general system position. At the same time, the cable moves the sector and pushrod of the system selector valve to the No. 1 position. The pushrod positions the system selector valve to the No. 1 bypass position. At the same time, the cables from the system selector valve sector move the auxiliary pump supply selector valve sector to No. 1 (auxiliary) position. The auxiliary pump supply selector valve remains in the auxiliary supply position through the idle feature of the sector rigging. In this condition, the engine-driven pump pressure is ported to the reservoir and the auxiliary pump supplies pressure to the general system. In this position, the fluid is supplied to the auxiliary pump from the low standpipe in the hydraulic system reservoir. To put the system into the alternate condition, the selector control lever is lifted out of detent and moved to the general system/main gear downlock and flaps position. The cables move the system selector valve sector to the No. 3 (alternate) position. The system selector valve sector moves the cables rotating the auxiliary pump supply selector valve sector to the No. 3 (alternate) position. As the sector rotates, the end of the arm moves away from the idle position. This positions the valves to the alternate position, supplying fluid to the auxiliary pump from the auxiliary pump alternate reservoir. In this position, fluid from the auxiliary pump is ported to the wing flap control valve and the main gear downlock cylinders. Engine-driven pump pressure is ported to the general system.



SYSTEM ENGINEERS PEDESTAL

FTX80085

Figure 29-27


A
R
ON
OFF
AIL
RUD
HYD PWR SHUTOFF
GENERAL SYSTEM ◄ ENG PUMP OUTPUT ►
MAIN GRDN LOCK&FLAPS ◄ AUX PUMP OUTPUT ►
GENERAL SYSTEM (NORMAL)
BYPASS ◄ ENG PUMP OUTPUT ►
GENERAL SYSTEM ◄ AUX PUMP OUTPUT ►
HYD SYS SELECTOR

HYDRAULIC SYSTEM SELECTOR

THE SELECTOR IS DETENTED IN THREE POSITIONS AND DETERMINES SOURCE OF HYDRAULIC FLUID AND ROUTING OF PRESSURE AS SHOWN.

POSITION	ENGINE PUMP	AUX PUMP
GEN. SYS./ MAIN GEAR DOWN LOCK AND FLAPS	MAIN RESERVOIR FLUID, IF AVAILABLE, IS ROUTED TO LEFT AND RIGHT MANIFOLDS..	EMERGENCY RESERVOIR FLUID IS ROUTED DIRECTLY TO MAIN GEAR DOWN LOCKS AND TO FLAP SYSTEM.
GENERAL SYSTEM (NORMAL)	MAIN RESERVOIR FLUID IS ROUTED TO LEFT AND RIGHT MANIFOLDS.	MAIN RESERVOIR FLUID IS ROUTED TO LEFT AND RIGHT MANIFOLDS. THE EMERGENCY RESERVOIR IS ISOLATED
BYPASS/ GENERAL SYSTEM	MAIN RESERVOIR FLUID IS RETURNED TO THE MAIN RESERVOIR BYPASSING MANIFOLDS.	MAIN RESERVOIR FLUID IS ROUTED TO LEFT ND RIGHT MANIFOLDS. THE EMERGENCY RESERVOIR IS ISOLATED

HYDRAULIC SYSTEM SELECTOR

Figure 29-28

FTX80086

2. Auxiliary - Description and Operation

C. General

(1) The auxiliary hydraulic system is a supplementary hydraulic power system connected to the main hydraulic power system through the system selector valve and the auxiliary pump supply selector valve. The auxiliary hydraulic system consists of an electrically driven auxiliary hydraulic pump, an auxiliary pump relief valve, a surge damper accumulator, an auxiliary filter and check valve, and the piping required to interconnect the components and connect the auxiliary system to the main power system.

(2) In flight, the auxiliary hydraulic system can be used as supplemental power for the main power system. The auxiliary pump will also serve, when ground support equipment is not available, to pressurize the hydraulic power system for ground testing of the airplane hydraulic subsystems and components. Fluid is supplied to the auxiliary pump from a low standpipe in the hydraulic system reservoir. When the auxiliary pump is operated, fluid from the pressure outlet port of the auxiliary pump is ported, through the auxiliary power system filter and an auxiliary system check valve, to the auxiliary pressure inlet port of the system selector valve. When the system selector valve is in the normal position, auxiliary pump pressure is ported to the general system.

(3) When the auxiliary pump is not operating, the auxiliary system check valve prevents reverse flow through the auxiliary pump from the engine-driven pumps. An auxiliary pump relief valve is teed into the line from the auxiliary pump outlet port to the reservoir filter inlet port. The valve relieves and ports excess fluid pressure back to the reservoir if auxiliary pressure builds above 3300 psi.

(4) The auxiliary pump alternate reservoir is installed in the auxiliary hydraulic system to provide an alternate hydraulic fluid source in case of depletion of the normal supply in the hydraulic system reservoir. The alternate reservoir source is selectable by operation of the auxiliary hydraulic pump supply selector valve which actuates simultaneously with the hydraulic system selector valve.

D. System Components

(1) Auxiliary Hydraulic Pump (See Figure 29-29)

(a) The auxiliary hydraulic pump, located in the left wing root access area, supplies hydraulic pressure for the auxiliary hydraulic system. The pump consists of an air cooled electric motor directly coupled through a shaft and centrifugal boost pump impeller to a variable displacement hydraulic pump.

(b) The electric motor is a 115/200-volt, 3-phase, 400-cps, continuous duty motor rated at 6.5 hp at 11,300 rpm. The motor rotor has an internally splined output shaft which fits on the externally splined input shaft of the pump. The other end of the rotor shaft drives a cooling fan which forces cooling air between the motor case and the outer shroud. A thermoswitch located in the motor case is provided to shut off the motor case of an overheat condition. An override function of the control switch in the flight compartment is provided to override the thermoswitch for emergency operation.

(c) The centrifugal boost pump impeller is located on the drive shaft between the motor and the variable displacement pump. The impeller draws hydraulic fluid from the system and supplies it through an external tube to the inlet port of the variable displacement pump under pressure, thereby helping to prevent cavitation of the pump.

(d) The variable displacement hydraulic pump consists of the following major parts; a four piece housing, drive shaft with impeller, axial cylinder barrel containing 9 pistons, pivoting hangar with an inclined camface, hold down plate, pressure compensating valve, and bearings.

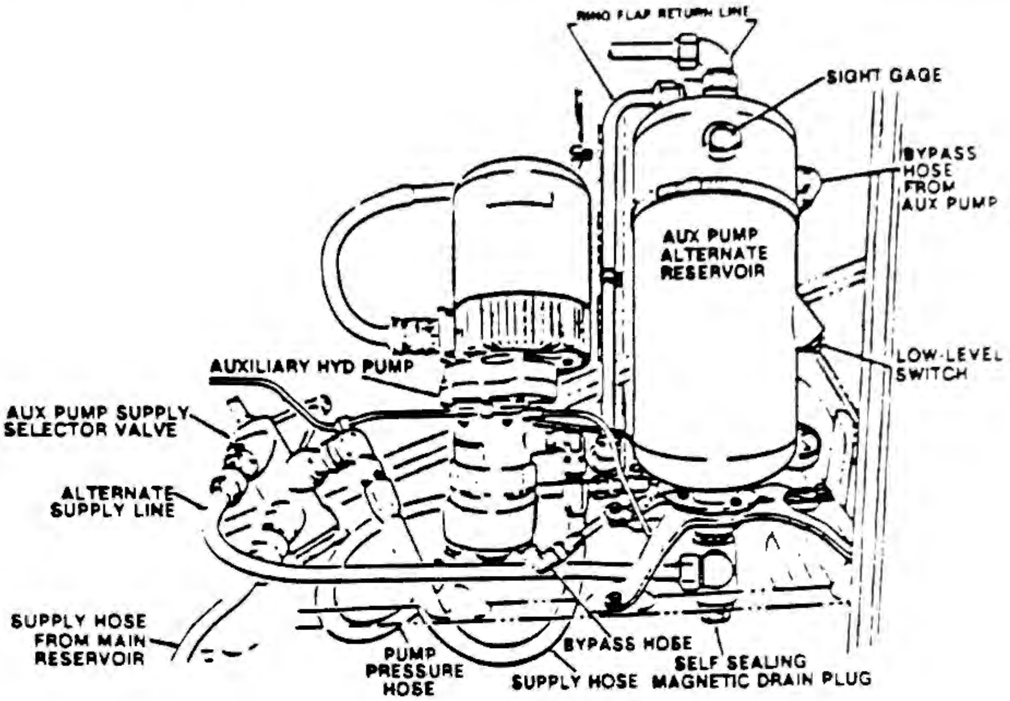
(e) When the electric motor is actuated, the drive shaft rotates the boost pump impeller and the cylinder and piston group. Each revolution of the cylinder causes one complete stroke of each piston. The pistons are held against the camface of the hangar by the hold down plate, providing positive piston return. The displacement of fluid from the pump discharge port is controlled by the compensator valve. The pump provides full flow of 3.9 gpm at system pressures up to approximately 2700 psi. At this point, the compensator valve reduces flow until at approximately 3000 psi, displacement of fluid is reduced to zero.

(2) Auxiliary Hydraulic Pump Alternate Reservoir

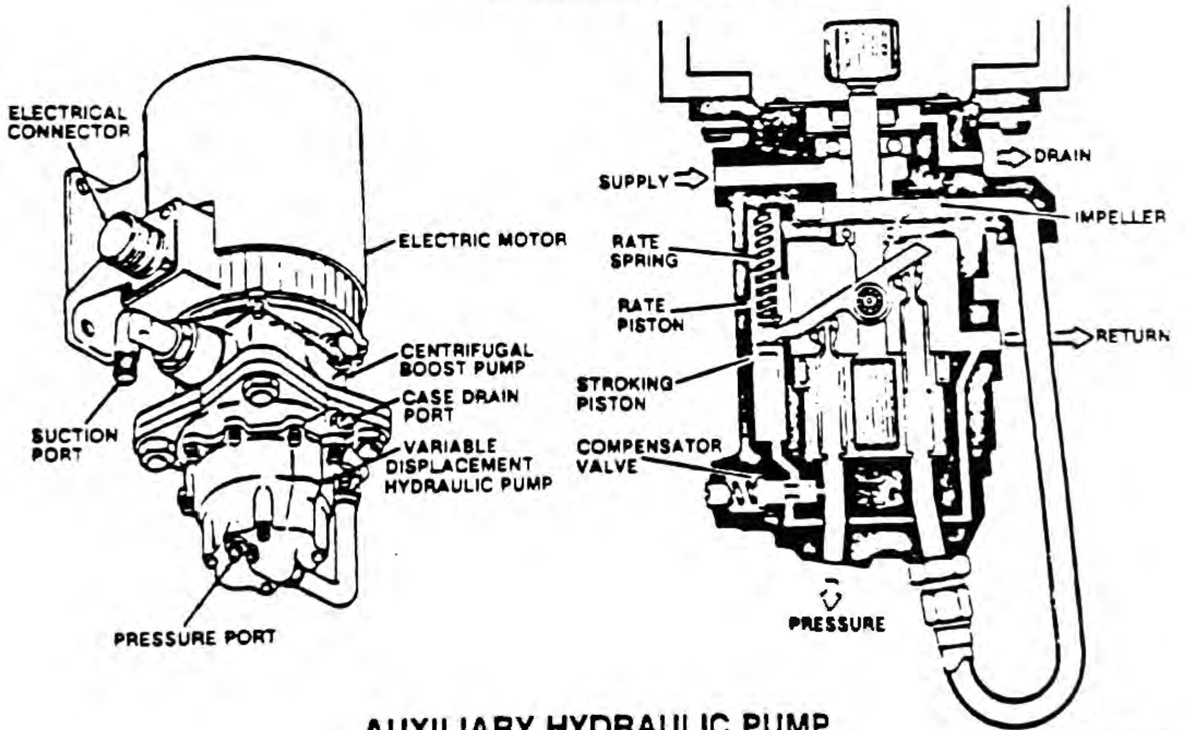
(a) The auxiliary hydraulic pump alternate reservoir is installed on the shear web in the left wing root area, immediately aft of the auxiliary hydraulic pump. Access to the reservoir is through the left wing root access door. The alternate reservoir supplies hydraulic fluid to the auxiliary hydraulic pump in the event the fluid supply from the main hydraulic system reservoir is exhausted.

(b) The reservoir is cylindrical in shape and has a fluid capacity of approximately 1.9 US gallons. There are four ports on the reservoir: an outlet port to the auxiliary hydraulic pump selector valve located at the bottom, an inlet port from the auxiliary hydraulic pump case drain located near the top on the side, an inlet from the wing flap return line, and an outlet to the main hydraulic reservoir located at the top. A sight gage is installed near the top of the reservoir for visual indication of fluid level, and a mounting boss for the emergency hydraulic level indicating light switch is installed on the side of the reservoir.

(c) The reservoir is kept full during operation by routing fluid from the wing flap return line to the reservoir. Fluid in excess of the alternate reservoir capacity is then routed to the main hydraulic system reservoir. Hydraulic fluid from the auxiliary pump case drain is routed to the alternate reservoir and then to the main reservoir. Fluid is used from the alternate reservoir only when the auxiliary pump is operating and the auxiliary pump supply selector valve is in the alternate position. Fluid supply to the alternate reservoir is replenished whenever the wing flaps are operated.


WING FLAP RETURN LINE
SIGHT GAGE
BYPASS HOSE FROM AUX PUMP
AUX PUMP ALTERNATE RESERVOIR
LOW-LEVEL SWITCH
AUXILIARY HYD PUMP
AUX PUMP SUPPLY SELECTOR VALVE
ALTERNATE SUPPLY LINE
SUPPLY HOSE FROM MAIN RESERVOIR
PUMP PRESSURE HOSE
BYPASS HOSE
SUPPLY HOSE
SELF SEALING MAGNETIC DRAIN PLUG

AUXILIARY SYSTEM COMPONENTS INSTALLATION



AUXILIARY HYDRAULIC PUMP

FTX80087

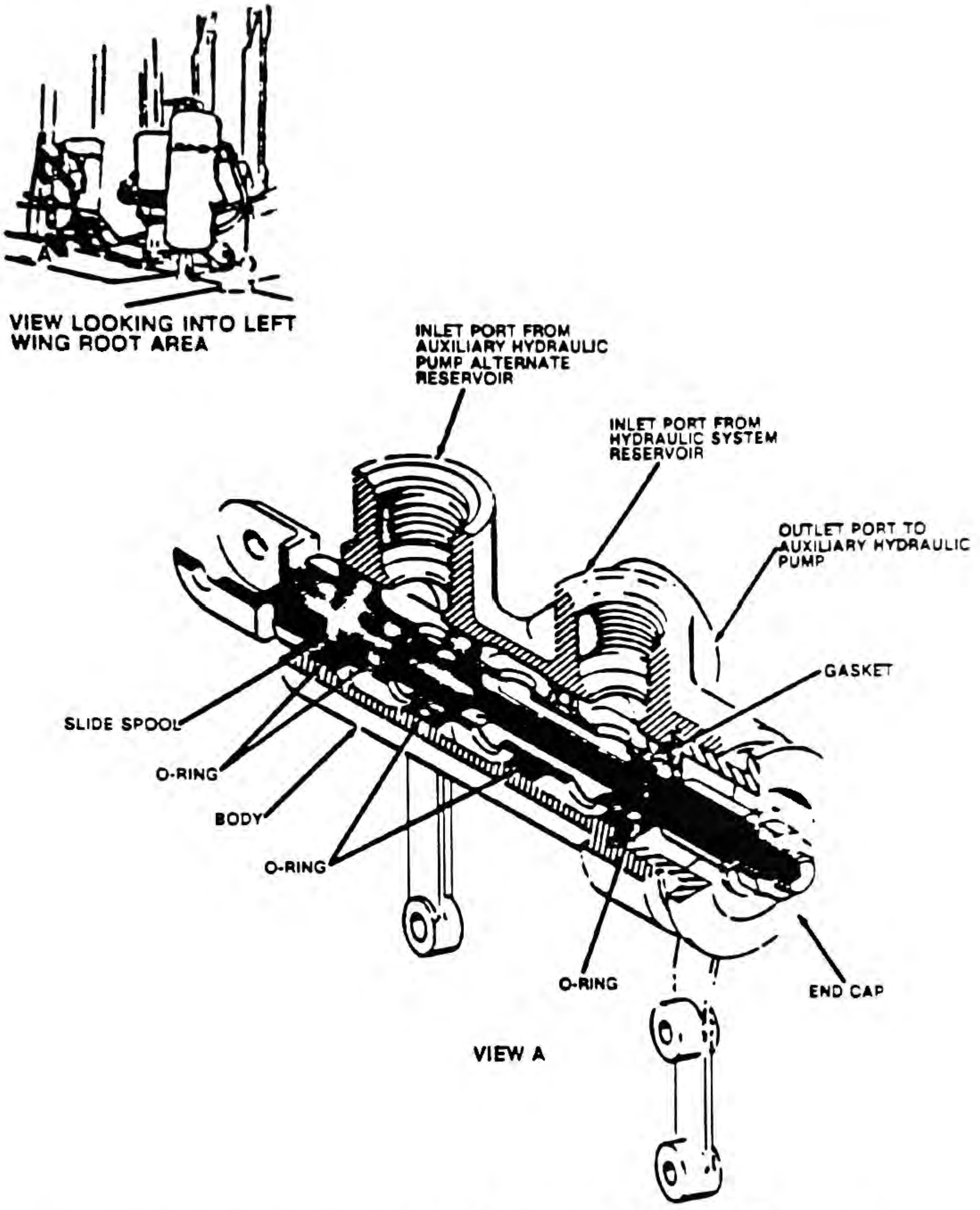
Figure 29-29

(3) Auxiliary Hydraulic Pump Supply Selector Valve (See Figure 29-30)

(a) The auxiliary hydraulic pump supply valve is a 2-position valve that ports hydraulic fluid from either reservoir, through a common outlet, to the auxiliary pump. The selector valve is located on the shear web in the left wing root, near the auxiliary pump. The selector valve is accessible through the left wing root access door.

(b) The valve body has two inlet ports and one outlet port. The outlet port is centrally located on the aft side of the valve body. The two inlet ports are located on the outboard side of the valve body, 90 degrees from the outlet port. Two mounting flanges are located on the inboard side of the valve body. These flanges are an integral part of the valve body.

(c) During normal operation, fluid is taken from a low standpipe in the main hydraulic system reservoir and ported to the auxiliary pump. When the valve is in the alternate position, fluid is taken from the auxiliary hydraulic pump alternate reservoir and ported to the auxiliary pump. The valve is moved from the auxiliary position to the alternate position by placing the hydraulic system selector control lever, located on the system engineer's control pedestal, to the general system/main gear downlock and flaps position.


A
VIEW LOOKING INTO LEFT WING ROOT AREA
INLET PORT FROM AUXILIARY HYDRAULIC PUMP ALTERNATE RESERVOIR
INLET PORT FROM HYDRAULIC SYSTEM RESERVOIR
OUTLET PORT TO AUXILIARY HYDRAULIC PUMP
GASKET
SLIDE SPOOL
O-RING
BODY
O-RING
O-RING
END CAP
VIEW A

AUXILIARY HYDRAULIC PUMP SUPPLY SELECTOR VALVE

FTX80088

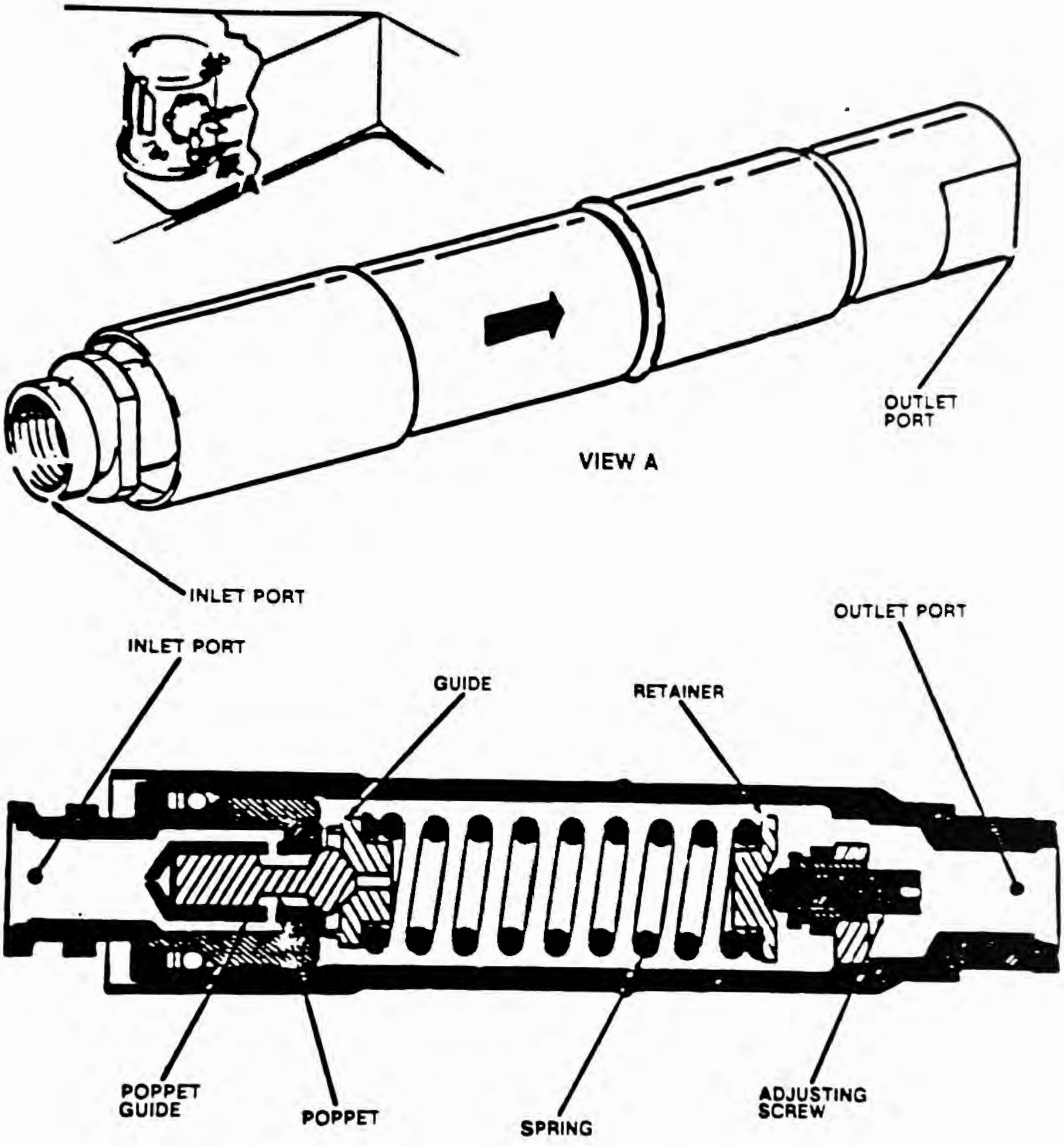
Figure 29-30

(4) Auxiliary Hydraulic Pump Relief Valve (See Figure 29-31)

(a) The auxiliary hydraulic pump relief valve is a spring loaded poppet-type valve and serves to relieve excess fluid pressure that may build up in the auxiliary hydraulic system. The relief valve connects, through a reducer, to a tee in the A return port of the hydraulic system reservoir. The valve is accessible through the left wing root access door.

(b) Externally, the valve body is cylindrical, approximately 5 inches in length, and 1 inch in diameter. The outlet end of the valve is slightly larger than the inlet end.

(c) When pressure builds up, the poppet starts to relieve at approximately 3300 psi. If pressure continues to build up, the poppet continues to open until 3500 psi and a maximum flow of 3.5 gpm are reached. When pressure is relieved, the poppet reseats at 90 percent of the unseat pressure.



AUXILIARY HYDRAULIC PUMP RELIEF VALVE

FTX80089

Figure 29-31

(5) Auxiliary Hydraulic System Filter (See Figure 29-32)

(a) A line-type, 10 micron filter assembly is installed in the piping of the auxiliary system to filter fluid from the pressure outlet port of the auxiliary pump to the system selector valve. The filter is located on the bulkhead near the forward inboard corner of the left main gear wheel well, slightly inboard and above the dual filter and relief valve. It is accessible through the left main gear inboard door.

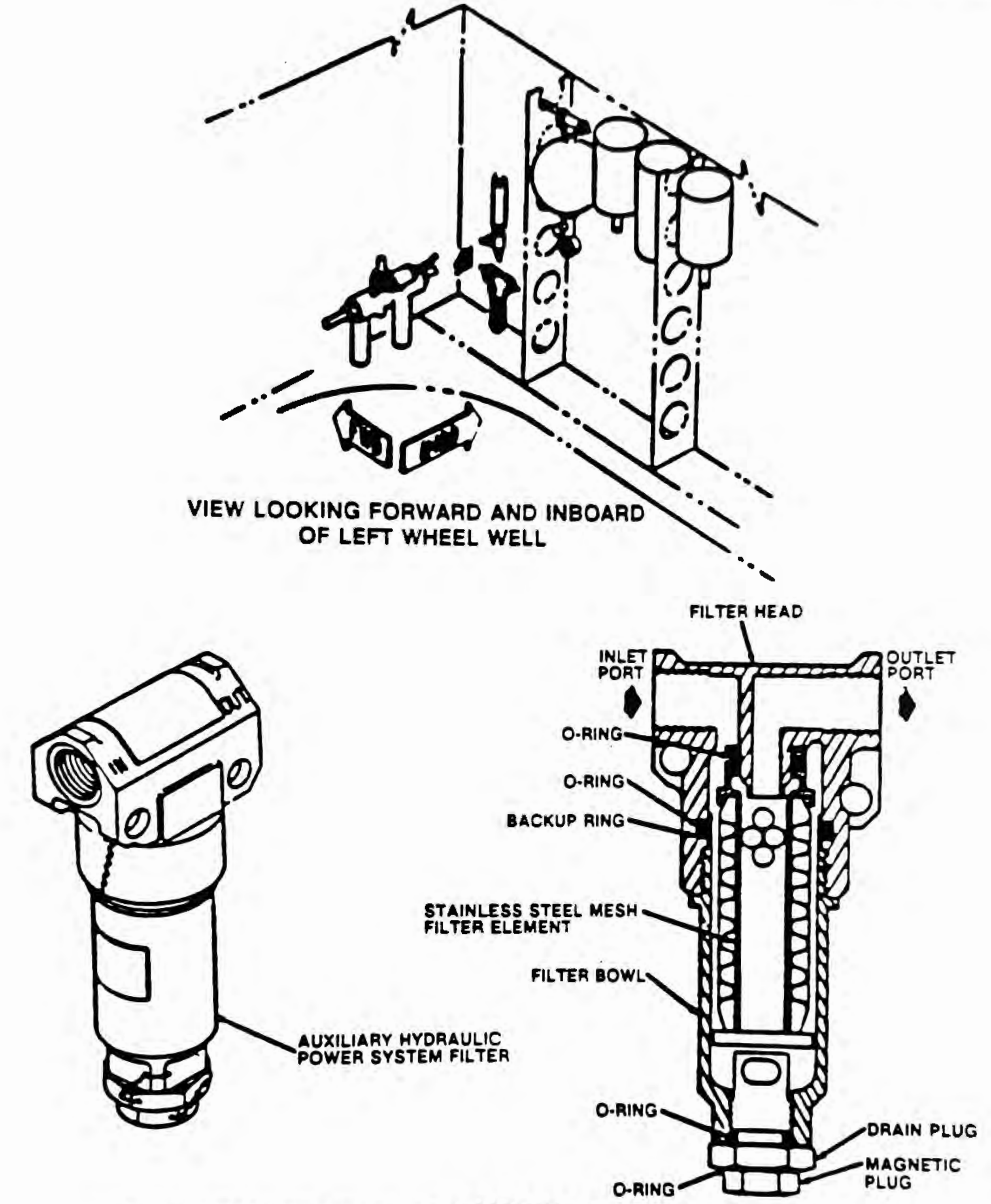
(b) The inlet and outlet ports of the filter are internally threaded and are marked in and out. The filter bowl is cylindrical in shape, with wrench flats at the lower end, and is threaded into the assembly immediately below the ports. A hex-shaped magnetic plug is installed in the drain port. The filter element is stainless steel mesh, supported by a perforated cylindrical center core.

(6) Auxiliary Hydraulic System Check Valve

(a) The auxiliary hydraulic system check valve is a spring-loaded, poppet-type valve with a rated capacity of 3000 psi. This valve is installed in the line between the auxiliary hydraulic system filter and the system selector valve to prevent reverse flow of hydraulic fluid through the filter and the auxiliary pump when the engine-driven pumps or external pressure supply are used.

(b) The auxiliary hydraulic system check valve is located in the left wheel well, just above the dual filter and relief valve. The auxiliary hydraulic system check valve is accessible through the left wheel well.

(c) Externally and internally, this valve is similar to the engine-driven hydraulic pump check valve, except for size.


VIEW LOOKING FORWARD AND INBOARD OF LEFT WHEEL WELL
FILTER HEAD
INLET PORT
OUTLET PORT
O-RING
O-RING
BACKUP RING
STAINLESS STEEL MESH FILTER ELEMENT
FILTER BOWL
AUXILIARY HYDRAULIC POWER SYSTEM FILTER
IN
O-RING
DRAIN PLUG
MAGNETIC PLUG
O-RING
FTX80090

AUXILIARY HYDRAULIC SYSTEM FILTER

Figure 29-32

(7) Auxiliary Hydraulic System Surge Damper Accumulator (See Figure 29-33)

(a) The auxiliary hydraulic system surge damper accumulator consists of two spherical domes, separated by a diaphragm and held together by a ring nut. An air filler valve and gage are installed on the accumulator. The accumulator is installed in the auxiliary hydraulic pump pressure line just inboard and aft of the auxiliary pump, and is attached to the shear web by two clamp blocks. Access to the accumulator is through the left wing root access door.

(b) The accumulator is initially charged to 1000 psi with dry nitrogen. As the auxiliary system pressure builds up, fluid is forced against the diaphragm in the accumulator, further compressing the trapped nitrogen in the air side of the accumulator to full system pressure (2600 to 3000 psi is indicated on the accumulator pressure gage). The air in the accumulator absorbs the initial shock of the auxiliary pump output and permits the system pressure to rise gradually. The accumulator also serves the cushion the piping and system components against high impact loads.

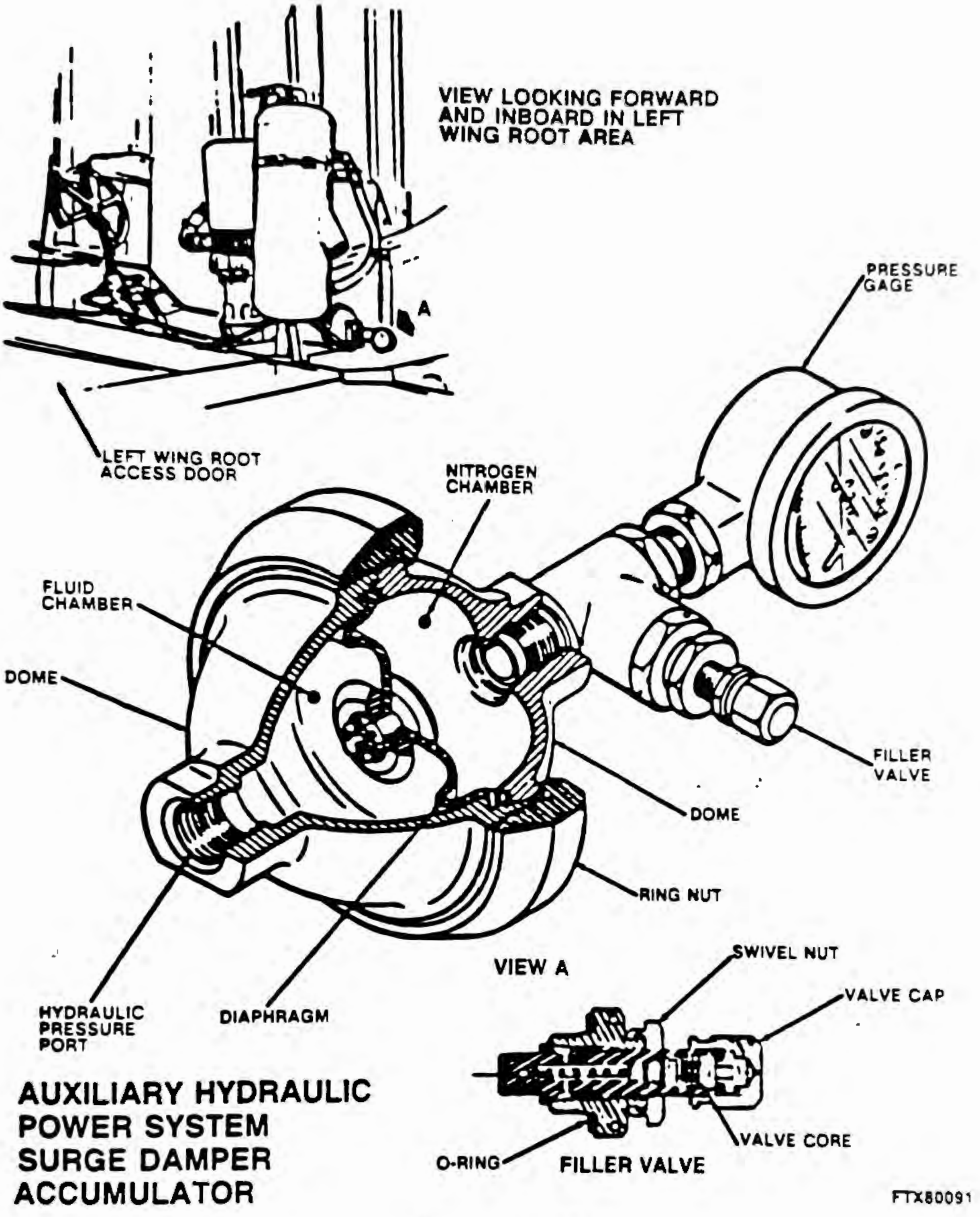

VIEW LOOKING FORWARD AND INBOARD IN LEFT WING ROOT AREA
A
LEFT WING ROOT ACCESS DOOR
PRESSURE GAGE
NITROGEN CHAMBER
FLUID CHAMBER
DOME
FILLER VALVE
DOME
RING NUT
VIEW A
SWIVEL NUT
VALVE CAP
HYDRAULIC PRESSURE PORT
DIAPHRAGM
VALVE CORE
O-RING
FILLER VALVE
AUXILIARY HYDRAULIC POWER SYSTEM SURGE DAMPER ACCUMULATOR
FTX80091

Figure 29-33

(8) Auxiliary Hydraulic Pump Control

(a) The auxiliary hydraulic pump control system consists of auxiliary hydraulic pump control switch, an auxiliary hydraulic pump control relay, an auxiliary hydraulic pump power relay, an electric motor, and an auxiliary pump on indicating light.

(b) The auxiliary hydraulic pump control switches, located in the flight compartment, are 3-position switches. They are spring-loaded to the center position and have two momentary positions placarded start (hold only in emergency) and stop.

(c) The electric motor for the auxiliary hydraulic pump is an ac, 3-phase motor. A thermostatic switch is included in the circuit to protect the motor from overheating.

(d) The auxiliary hydraulic pump motor is supplied with power from the cabin bus 4. This permits pump operation from an external power source or from the airplane electrical system.

(e) The auxiliary pump on indicating light is a blue press-to-test light, located adjacent to the auxiliary hydraulic pump control switch. The light is equipped with a dimming feature.

(f) When the auxiliary hydraulic pump control switch is momentarily moved to the start position, the circuitry is completed between the auxiliary hydraulic pump control relay and cabin bus 4. The ground is through the stop contact of the switch and the thermostatic switch of the motor. Once the relay is energized, it remains energized through its own holding contacts. Through a closed contact of the pump control relay, power is supplied from cabin bus 4 to energize the hydraulic pump power relay. Through the closed contacts of the pump power relay, a power circuit is completed from the feeder leads of cabin bus 4 to the auxiliary hydraulic pump motor. The blue indicating light, located on the overhead switch panel, receives power through one of the closed contacts of the pump power relay. Therefore, the light is on whenever the pump power relay is energized.

(g) The auxiliary hydraulic pump motor is safeguarded against overheating by the thermostatic switch. Under normal conditions, this switch is in the ground leg of the control relay. When an overheat condition occurs, the thermostatic switch opens the control relay circuit to limit the motor case to 450° F (252° C). This action deenergizes the control relay, which in turn deenergizes the power relay. In an emergency situation, the thermostatic switch can be overridden by holding the auxiliary hydraulic pump control switch in the start (hold only in emergency) position.

(h) When the auxiliary hydraulic pump control switch is placed in the momentary stop position, the ground for the control relay is broken, deenergizing the power relay and removing power from the pump motor and the indicating light.

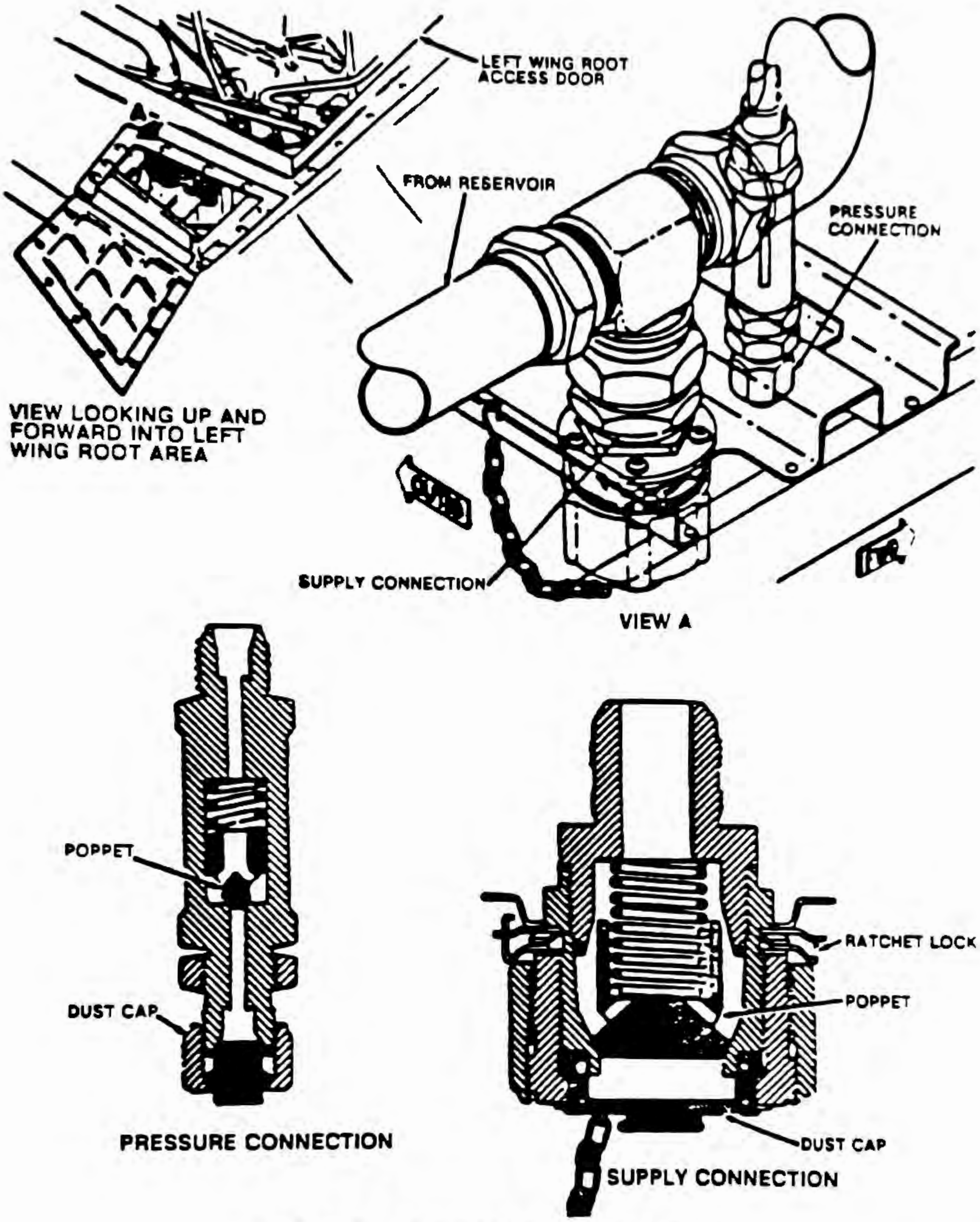
(9) Ground Service Pressure and Supply Connectors (See Figure 29-34)

(a) The ground service pressure and supply connectors are external fittings to which a service unit can be connected for operating the hydraulic power system when there is no power on the airplane. The connectors are located on a panel covered by an access door on the lower skin of the left wing root, aft of the rear spar.

(b) The ground service pressure connector is made up of a check valve with a flared, bulkhead-type fitting on the inlet end and a standard tube fitting on the outlet end which connects to the left engine-driven pump pressure line. The inlet fitting is covered with a dust cap when not in use.

(c) The internal description of the connector is the same as that of the engine-driven hydraulic pump check valve. The connector operates as a shutoff valve when the ground unit is not connected. When a ground hydraulic power source is connected to the pressure connector and pressure is applied, the poppet unseats and supplies pressure fluid to the hydraulic power system.

(d) The supply connector is made up of a T-fitting and a self-sealing coupling half. The tee is female-threaded to accept the bulkhead-type fitting on the upper end of the coupling. The cross arms of the tee tie into the right engine-driven pump supply line with flared-type fittings. The tee is threaded onto the coupling half and is secured with a locknut. The coupling consists of a coupling body, male-threaded to accept the coupling half from the ground source. The mounting flange has a recess to accept the hex portion of the coupling body, and has notches to retain the lockspring. A dust cap consisting of a union nut assembly, a dust plug, and a securing chain is installed on the lower end of the coupling when not in use.



GROUND POWER CONNECTORS

FTX80092

Figure 29-34

2. Indicating - Description and Operation

A. General

(1) Description

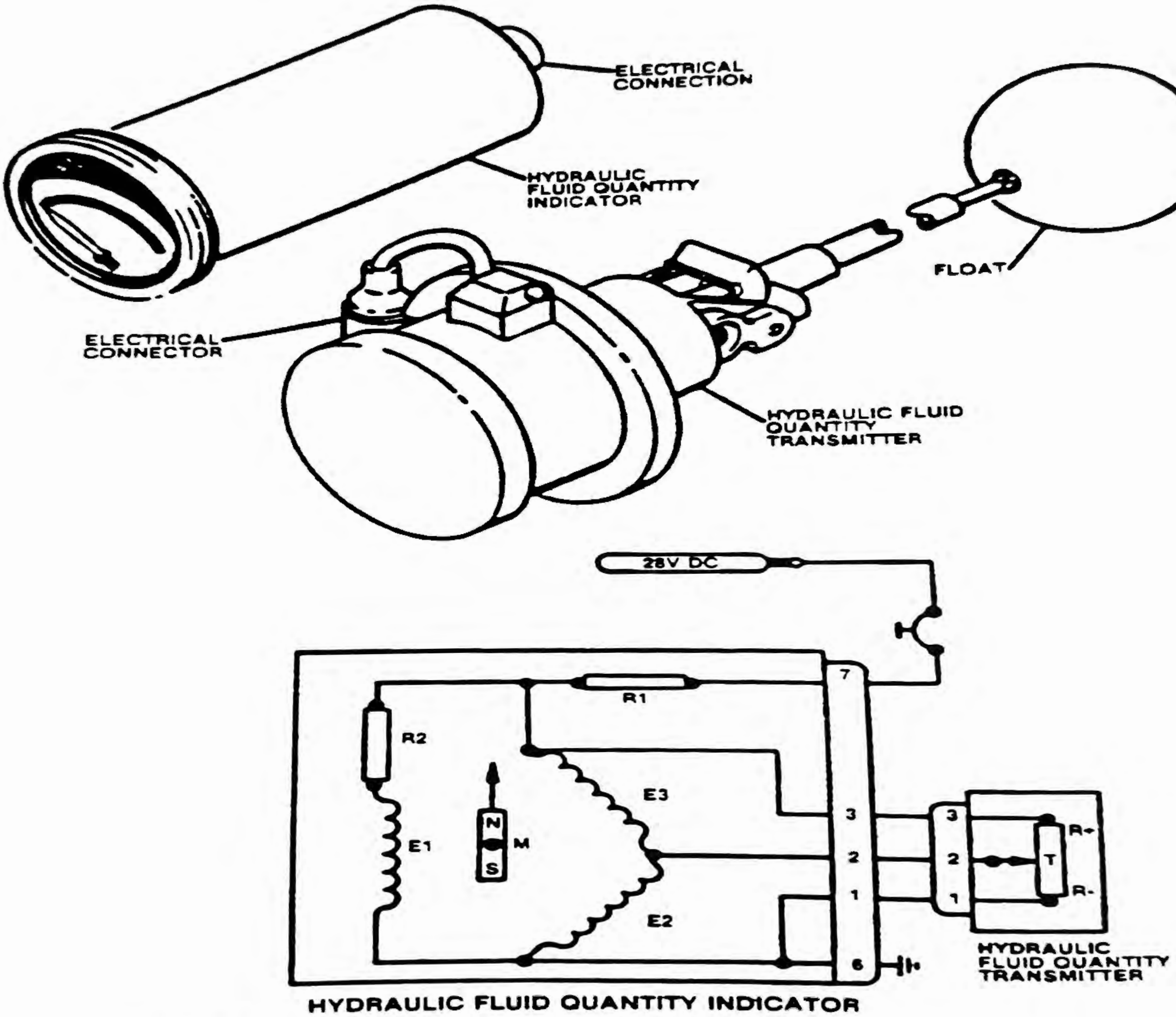
(a) Indicating circuits for the hydraulic power system provide indications in the flight compartment of the status of the hydraulic power system during operation. Five separate indications are provided; three (hydraulic fluid quantity, temperature, and pressure) are presented on indicating gages and three (hydraulic reservoir low pressure, hydraulic fluid overtemperature, emergency reservoir fluid level) are presented by indicating lights.

(2) Hydraulic Fluid Quantity Indicating System (See Figure 29-35)

(a) The hydraulic fluid quantity indicating system consists of a ratiometer-type indicator, a tank unit (transmitter) bolted to an external flanged adapter on the reservoir, and interconnecting wiring. Changes in the fluid level in the hydraulic system reservoir are followed by a float. The motion of the float is transmitted by means of a linkage arrangement, to the contact arm (wiper arm) of a potentiometer inside of the head of the transmitter. The potentiometer is wired to the indicator. The indicator consists of a rotor surrounded by three electromagnets. As the potentiometer contact arm moves, the indicator rotor is positioned accordingly. The indicator pointer is attached directly to the rotor and thus shows liquid quantity. The indicator is marked hydraulic oil quantity.

(b) When the hydraulic reservoir is full, the fluid quantity indicator in the flight compartment pegs at a point equivalent to 11.5 US gallons. There are 1.4 US gallons in the reservoir not recorded; as a result, the indicator does not move until this amount of fluid is depleted.

(c) In operation, the voltage across E1 is constant. The position of the contact arm (wiper arm) in the transmitter determines the voltage across E2 and E3. When the contact arm in the transmitter is moved in the R+ direction, the voltage across coil E2 is increased while the voltage across E3 is decreased. When the contact arm is moved in the R-direction, the opposite effect takes place. From these voltages, magnetic flux is produced in each coil proportional to the voltage drop across the coil. The electrical circuit causes the resultant of the three coil fluxes to rotate in a clockwise direction, as the contact arm is moved toward the R-position. The permanent magnet (M) reacts with the resultant flux, producing a torque which causes the magnet to rotate and become magnetically aligned with the resultant coil flux. Moderate supply voltage variation does not affect the positioning of the pointer on the indicator scale. A voltage variation affects each of the coils proportionately, therefore affecting only the magnitude of the resultant flux, but not the direction. When the system power is off, a magnet in the indicator pulls the pointer off the scale.


ELECTRICAL CONNECTION
HYDRAULIC FLUID QUANTITY INDICATOR
FLOAT
ELECTRICAL CONNECTOR
HYDRAULIC FLUID QUANTITY TRANSMITTER
28V DC
7
R1
R2
E3
E1
N
M
S
E2
3
2
1
6
R+
T
R-
HYDRAULIC FLUID QUANTITY TRANSMITTER
HYDRAULIC FLUID QUANTITY INDICATOR

HYDRAULIC FLUID QUANTITY INDICATING SYSTEM

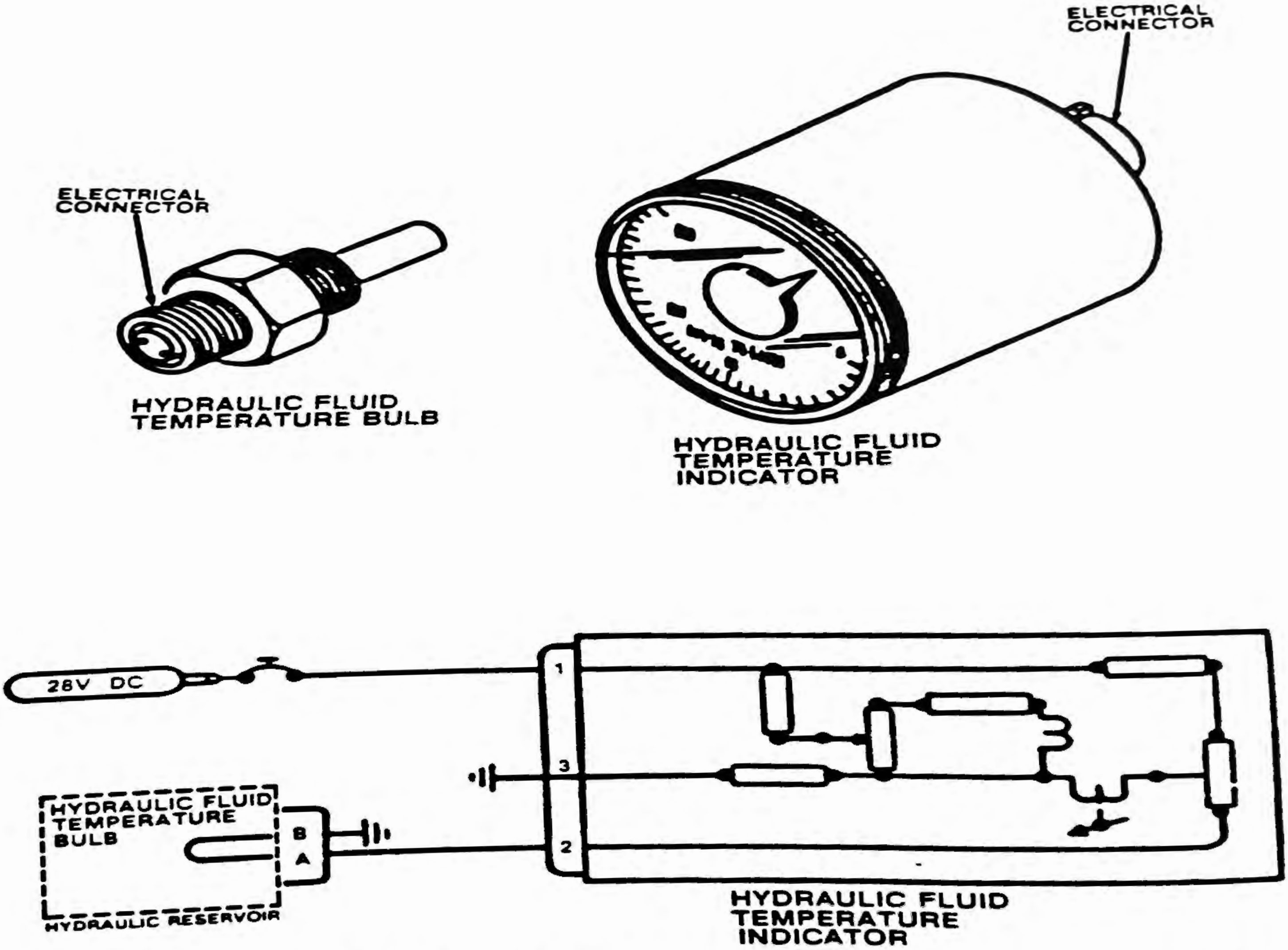
FTX80093

Figure 29-35

(3) Hydraulic Fluid Temperature Indicating System (See Figure 29-36)

(a) The hydraulic fluid temperature indicating system is the ratiometer-type which provides an indication of hydraulic fluid temperature in the reservoir. The system consists of a temperature bulb, installed in the reservoir, and an indicator in the flight compartment.

(b) The hydraulic fluid temperature indicator operates on the electrical bridge principle, with the temperature bulb forming one leg of the bridge circuit. The indicator armature has two coils turning in the air gap of permanent magnets. A large deflecting coil functions much the same as a galvanometer. A small restoring coil is connected in series with one leg of the bridge and opposes the motion of the deflecting coil. Three hairsprings connect the coils to the circuit; one is common to both coils. Two slide-wire potentiometers are provided; one adjusts calibration at center scale and the other expands or contracts the scale ends. When deenergized, a spring-operated device returns the pointer to a position below the scale arc. The indicator is calibrated from -50° C to +150° C (-58° F to 302° F). The temperature bulb has a range of -70° C to +300° C (-94° F to 572° F).


ELECTRICAL CONNECTOR
ELECTRICAL CONNECTOR
HYDRAULIC FLUID TEMPERATURE BULB
HYDRAULIC FLUID TEMPERATURE INDICATOR
28V DC
1
3
2
HYDRAULIC FLUID TEMPERATURE BULB
B
A
HYDRAULIC RESERVOIR
HYDRAULIC FLUID TEMPERATURE INDICATOR

HYDRAULIC FLUID TEMPERATURE INDICATING SYSTEM

FTX80094

Figure 29-36

(4) Hydraulic Fluid Pressure Indicating System (See Figure 29-37)

(a) The hydraulic fluid pressure indicating system is the synchro-type and indicates the fluid pressure in the hydraulic power system. The system consists of an indicator, located in the flight compartment, and a transmitter. The transmitter is located in the upper right side of the nosewheel well and is connected by tubing to the hydraulic system pressure lines.

(b) The hydraulic fluid pressure indicator consists of a pointer mounted on the shaft of a synchro repeater and is contained within a non-hermetically sealed aluminum case. The indicator is electrically connected to a 28-vac, 400-cycle power source and to a remote, synchro-type pressure transmitter. The indicator is internally lighted by a 5.4-volt lamp bulb.

(c) The stator and rotor of the synchro repeater are electrically connected in parallel to the stator and rotor of the remote pressure transmitter. When both units are energized from the same source, the repeater rotor assumes an identical position to that of the transmitter rotor, which is positioned by action of hydraulic pressure. Thus, the indicator indicates the pressure on the dial which is calibrated in psig from 0 to 4 times 1000. If the system electrical power fails, the point tends to remain at the last indicated position. A direct-reading gage, located on the hydraulic system accumulator in the left main gear wheel well, also indicates the hydraulic system pressure.

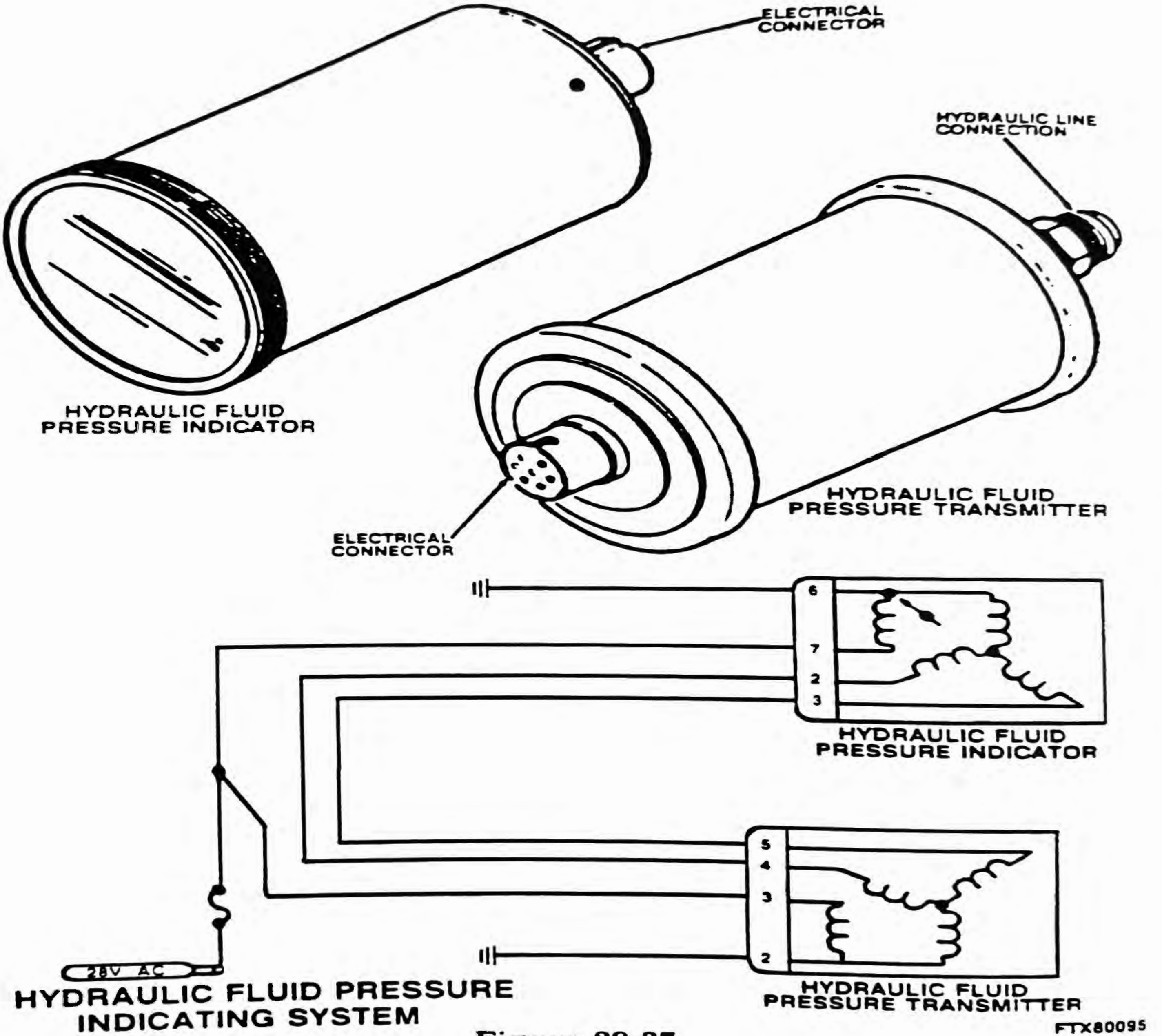

ELECTRICAL CONNECTOR
HYDRAULIC LINE CONNECTION
HYDRAULIC FLUID PRESSURE INDICATOR
HYDRAULIC FLUID PRESSURE TRANSMITTER
ELECTRICAL CONNECTOR
6
7
2
3
HYDRAULIC FLUID PRESSURE INDICATOR
5
4
3
2
HYDRAULIC FLUID PRESSURE TRANSMITTER
28V AC
HYDRAULIC FLUID PRESSURE INDICATING SYSTEM
FTX80095

Figure 29-37

(5) Hydraulic Reservoir Low-Pressure Indicating Light System (See Figure 29-38)

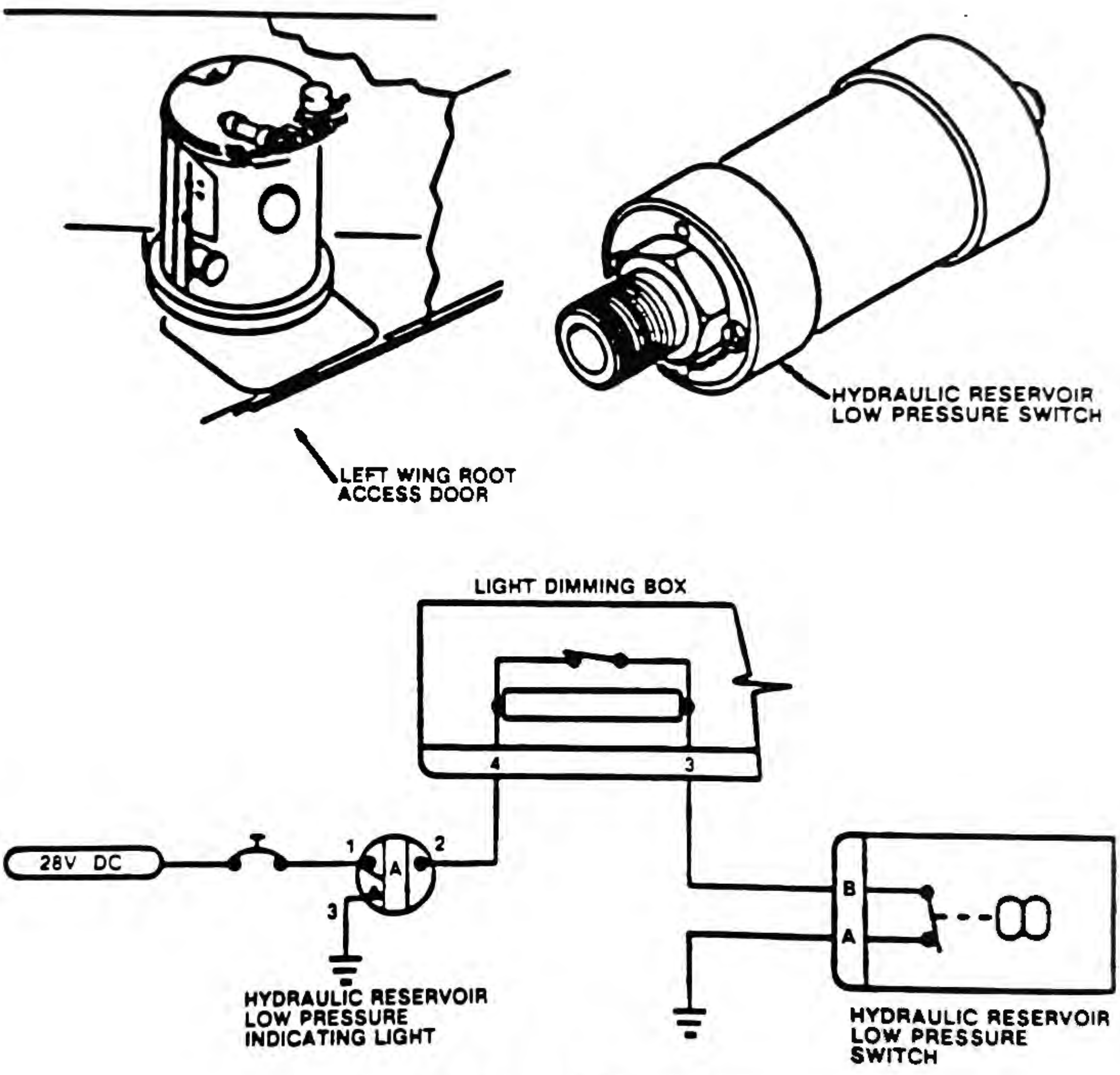
(a) The hydraulic reservoir low-pressure indicating light system provides a visual indicating of below normal air pressure in the hydraulic reservoir. The system consists of a pressure-actuated switch located on the hydraulic reservoir, a light-dimming switch and resistor, and a press-to-test amber indicator light in the flight compartment. The hydraulic reservoir low-pressure indicator light comes on when reservoir air pressure drops below 25 (±2) psi and goes off when the pressure reaches 30 (±2) psi.

(6) Hydraulic Fluid Overtemperature Indicating Light System (See Figure 29-39)

The hydraulic fluid overtemperature indicating light system provides a visual indication of overheated hydraulic fluid in the reservoir. The system consists of a dimmable, amber, press-to-test indicator light, and a temperature-sensitive switch installed in the hydraulic reservoir. The placard on the cap of the indicator light reads hydraulic oil temperature. If the hydraulic fluid reaches an over-temperature condition, the temperature-sensitive switch will cause the indicator light to come on. The switch closes when the temperature reaches 71° to 82°C (160°F to 180°F).

(7) Emergency Hydraulic Reservoir Low Level Indicating Light System (See Figure 29-40)

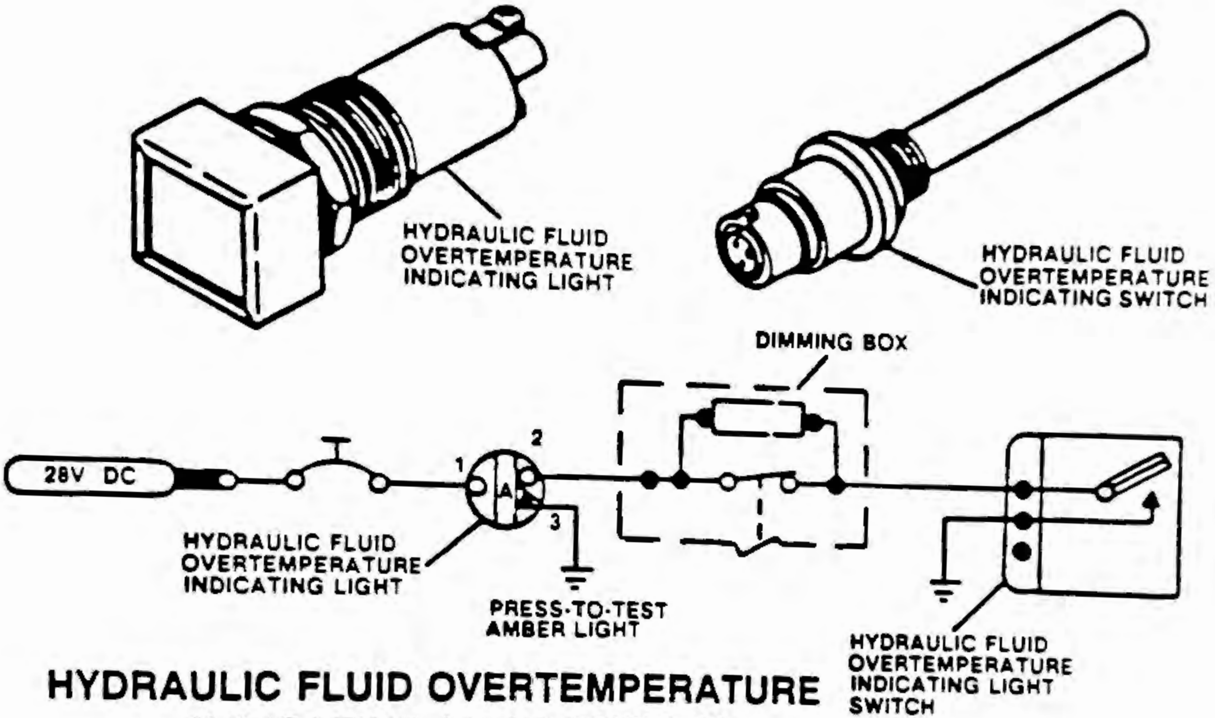
The emergency hydraulic reservoir low level indicating light system provides a visual indication in the flight compartment if the fluid level in the auxiliary hydraulic pump alternate reservoir drops to approximately 0.8 US gallons. The system consists of a float-actuated, 2-position switch located on the alternate reservoir, an indicator light located in the flight compartmnet, and the wiring required to connect the system. When fluid level in the alternate reservoir drops below 0.8 US gallons, the float lowers, closing the switch, and the indicator light comes on. When the fluid level rises above 0.8 US gallons, the float rises, opening the switch, and the light goes out.


LEFT WING ROOT ACCESS DOOR
HYDRAULIC RESERVOIR LOW PRESSURE SWITCH
LIGHT DIMMING BOX
4
3
28V DC
1
2
3
A
B
A
HYDRAULIC RESERVOIR LOW PRESSURE INDICATING LIGHT
HYDRAULIC RESERVOIR LOW PRESSURE SWITCH

HYDRAULIC RESERVOIR LOW-PRESSURE INDICATING LIGHT SYSTEM

FTX80096

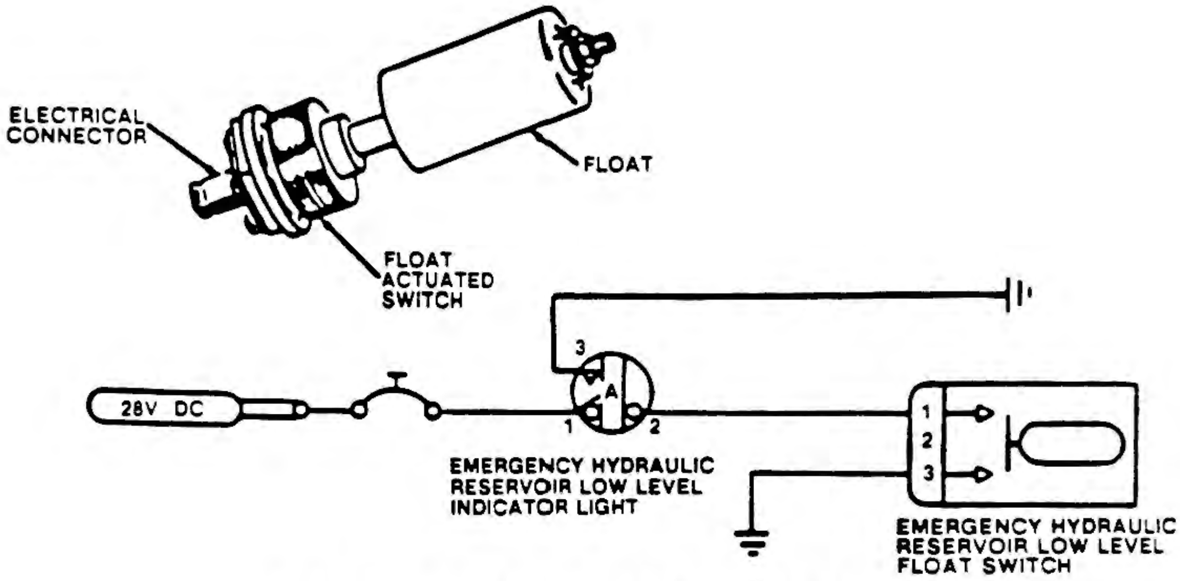
Figure 29-38


HYDRAULIC FLUID OVERTEMPERATURE INDICATING LIGHT
HYDRAULIC FLUID OVERTEMPERATURE INDICATING SWITCH
DIMMING BOX
28V DC
1
2
3
A
HYDRAULIC FLUID OVERTEMPERATURE INDICATING LIGHT
PRESS-TO-TEST AMBER LIGHT
HYDRAULIC FLUID OVERTEMPERATURE INDICATING LIGHT SWITCH

HYDRAULIC FLUID OVERTEMPERATURE INDICATING LIGHT SYSTEM

FTX80097

Figure 29-39


ELECTRICAL CONNECTOR
FLOAT
FLOAT ACTUATED SWITCH
28V DC
3
A
1
2
EMERGENCY HYDRAULIC RESERVOIR LOW LEVEL INDICATOR LIGHT
1
2
3
EMERGENCY HYDRAULIC RESERVOIR LOW LEVEL FLOAT SWITCH

EMERGENCY HYDRAULIC RESERVOIR LOW LEVEL INDICATING SYSTEM

FTX80098

Figure 29-40

3. Hydraulic Servicing (See Figure 29-41)

WARNING: SKYDROL PRECAUTIONS

A. Gravity Filling Procedure

(1) Deplete all hydraulic system pressure.

(2) Check initial air charge in all hydraulic accumulators.

(3) Pressurize system to 3000 psi check that aux. hydraulic pump emergency reservoir, rudder standby power system reservoir and thrust reverser reservoir are full.

(4) Ensure that the main and nose gear are extended, that flaps are up and thrust reversers are retracted. Brakes may be on or off.

(5) Shutoff hydraulic pressure source and deplete hydraulic fluid pressure from all hydraulic accumulators, except brake and nose wheel steering system return line accumulators.

(a) Air pressure in accumulators must be as follows:

1 System accumulator 1000 ± 50 psi

2 Rudder stby system 1000 ± 50 psi

3 Two nose steering accumulators 500 ± 50 psi

4 Horizontal stabilize/rudder accumulator 2000 ± 50 psi

5 Thrust reverser accumulators 1000 ± 50 psi

6 Press spring-loaded air bleed valve button, located in left wheel well to relieve air pressure in reservoir

a Place a cloth over holes in bleed valve to deflect escaping air and vaporized fluid

7 Cut safety wire and remove filler cap from filler assembly

8 Fill reservoir until level in sight gage is even with top arrow of gage.

CAUTION: DO NOT OVERFILL, AIR SPACE HAS BEEN CAREFULLY CALCULATED TO PROVIDE A FOAMING CHAMBER AND TO ABSORB SUDDEN SURGES OF FLUID RETURNING TO RESERVOIR.

9 Install filler cap and re-safety with lockwire

10 Service air chamber pressure to 30 to 35 psi

B. Pressure-fill Hydraulic System

(1) Deplete all system hydraulic pressure.

(2) Check initial air pressure in all hydraulic accumulators .

(3) Pressurize system and check all in line reservoirs are full.

(4) Ensure that main and nose gear are extended and flaps are up, and thrust reverser are retracted. Brakes may be on or off.

(5) Shut off hydraulic pressure source and deplete hydraulic fluid pressure from all hydraulic accumulators, except brake and nose steering return accumulators.

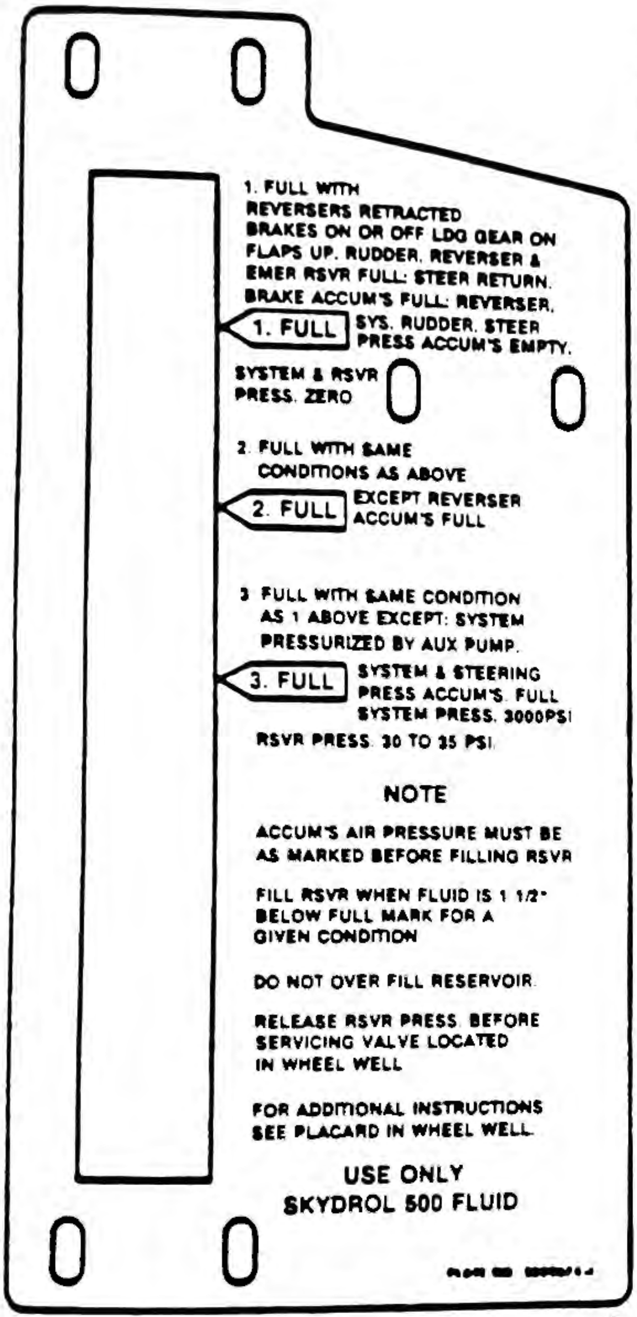
(a) Check that all accumulators read their correct precharge.

(6) Connect hydraulic test stand to ground service connections.

(a) Located under panel 547

(7) Press spring loaded air bleed valve button, located in left wheel well to relieve air pressure.

(a) Place cloth over bleed holes in air bleed valve to deflect escaping vaporized hydraulic fluid.



1. FULL WITH
REVERSERS RETRACTED
BRAKES ON OR OFF LDG GEAR ON
FLAPS UP. RUDDER, REVERSER &
EMER RSVR FULL: STEER RETURN.
BRAKE ACCUM'S FULL: REVERSER,

1. FULL SYS. RUDDER. STEER
PRESS ACCUM'S EMPTY.

SYSTEM & RSVR
PRESS. ZERO

2. FULL WITH SAME
CONDITIONS AS ABOVE

2. FULL EXCEPT REVERSER
ACCUM'S FULL

3 FULL WITH SAME CONDITION
AS 1 ABOVE EXCEPT: SYSTEM
PRESSURIZED BY AUX PUMP.

3. FULL SYSTEM & STEERING
PRESS ACCUM'S. FULL
SYSTEM PRESS. 3000PSI

RSVR PRESS. 30 TO 35 PSI.

NOTE

ACCUM'S AIR PRESSURE MUST BE
AS MARKED BEFORE FILLING RSVR

FILL RSVR WHEN FLUID IS 1 1/2"
BELOW FULL MARK FOR A
GIVEN CONDITION

DO NOT OVER FILL RESERVOIR.

RELEASE RSVR PRESS. BEFORE
SERVICING VALVE LOCATED
IN WHEEL WELL

FOR ADDITIONAL INSTRUCTIONS
SEE PLACARD IN WHEEL WELL.

USE ONLY
SKYDROL 500 FLUID

▲ VIEW B *

HYDRAULIC RESERVOIR SERVICING INSTRUCTIONS

USE ONLY SKYDROL 500 FLUID

DO NOT OVER FILL RESERVOIR

RELEASE RESERVOIR PRESSURE BEFORE SERVICING. VALVE AND GAGE LOCATED ADJACENT TO AIR CHAMBER.

CHECK ALL ACCUM'S FOR CORRECT AIR PRESSURE BEFORE FILLING RESERVOIR. ALL OIL MUST BE DEPLETED FROM ACCUM BEFORE CHECKING ACCUM AIR PRESSURE.

CHECK THAT EMER AND RUDDER RESERVOIRS ARE FULL. THESE RESERVOIRS ARE FILLED BY HYDRAULIC OPERATION OF FLAPS AND RUDDER.

EXCESSIVE AIR IN HYDRAULIC SYSTEM WILL NULLIFY SERVICING PROCEDURE TO CHECK - VARY RESERVOIR PRESSURE FROM 0 TO 40 PSI IF FLUID LEVEL CHANGE EXCEEDS 1/2" - BLEED SYSTEM.

VIEW C *

WARNING

RELIEVE AIR PRESSURE
BEFORE SERVICING
FILL WITH
SKYDROL
FLUID ONLY

VIEW D ** ***

▲ MARKINGS REQUIRED BY GOVERNMENT REGULATIONS

* LETTERING TO BE 1/8 INCH
** LETTERING TO BE 1/4 INCH
*** LETTERING TO BE 3/16 INCH

HYDRAULIC RESERVOIR DECALS

FTX80099

Figure 29-41

(8) Place hydraulic system selector valve lever to bypass position.

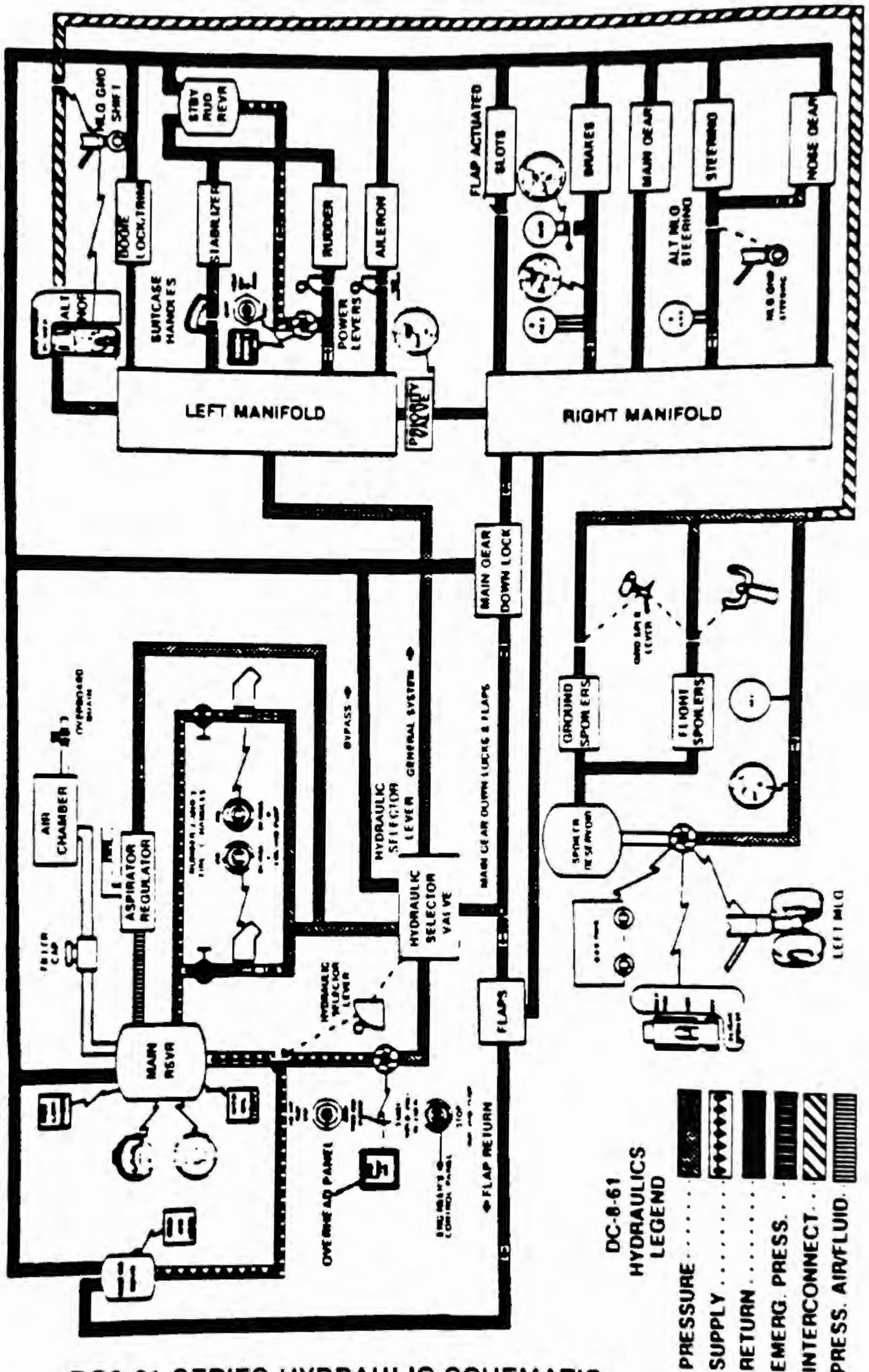
(9) Turn on test stand or pressure fill cart and carefully fill reservoir until fluid level in sight gage is approximately even with top arrow.

CAUTION: **RESERVOIR AIR SPACE HAS BEEN CAREFULLY CALCULATED TO PROVIDE A FOAM CHAMBER AND ABSORB SUDDEN SURGES OF FLUID RETURNING TO RESERVOIR.**

(10) Turn off test stand and disconnect service hoses.

4. 61 Differences

A. The differences of the 61 series aircraft is the location of a bogie lock and trim control valve on the left hydraulic manifold. (See Figure 29-42).



DC8-61 SERIES HYDRAULIC SCHEMATIC

FTX80100

Figure 29-42

B. Engine driven hydraulic pumps (See Figure 29-43 & 29-44)

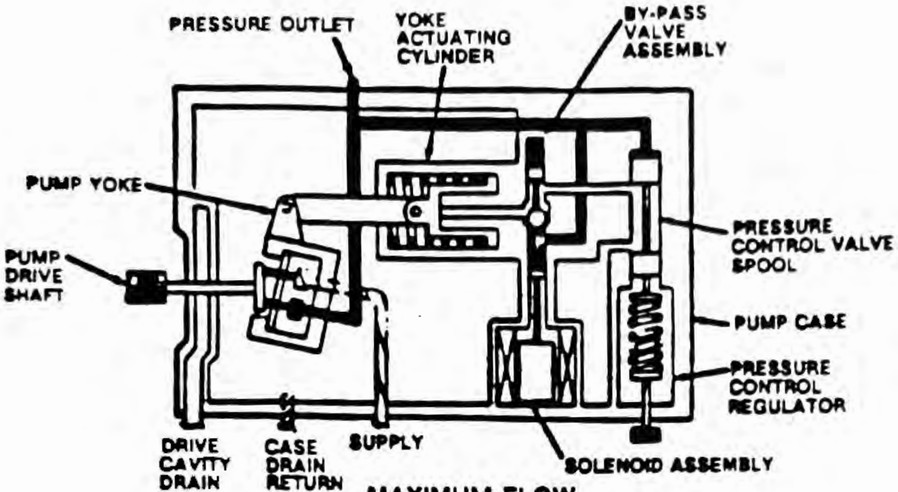
(1) A variable-displacement, pressure-compensated, engine-driven hydraulic pump is installed on each inboard engine. The pump incorporates a solenoid bypass feature for reducing the output of the pump. The bypass valves are controlled by two engine hydraulic pump control switches in the flight department. The switch for the hydraulic pump on engine NO.2 is placarded left, on and bypass. The switch for the hydraulic pump on engine No. 3 is placarded right, on and bypass. When either of the two engine hydraulic pump control switches is placed in the bypass position, the bypass valve solenoid for that hydraulic pump is energized, and the pump pressure decreases to 300 (+100) psi. When either switch is in the on position, the control circuit to the corresponding bypass valve is open and the hydraulic pump operates normally in the pressure range of 2850 to 3050 psi. The pump provides a continuous non-pulsating flow of hydraulic fluid. under pressure, to the hydraulic manifolds for distribution throughout the hydraulic system. Each of the engine-driven pumps is located on the accessory drive pad of the inboard engines. These pumps are accessible through the access doors on the right side of the nacelles and removal of the engine bypass duct.

(2) Three case drain ports are provided: two are on the yoke assembly housing, and the third is on the casing for the pressure control valve. adjacent to the inlet port fitting. The case drain port on top of the yoke assembly housing is used as the case drain connection to assure that the pump housing is full of fluid at all times. This drain connection is ported back to the low-pressure return port of the reservoir. The inlet port fitting is on top of the pump housing and the outlet port fitting is opposite to it on the bottom of the housing.

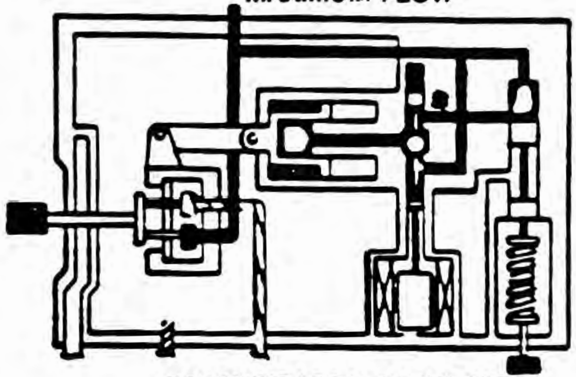
(3) The yoke control piston casing is an integral part of the pump case. Four self-locking nuts are used to hold the piston casing end-plate in position. The bypass valve assembly, consisting of the valve body and a solenoid, is mounted externally on the pump case, under the yoke control piston casing. This solenoid valve is provided with an electrical connector. A pressure control regulator is installed on the bypass valve body by means of four bolts. This regulator is cylindrical and is provided with an external adjustment screw. A lock screw is used to retain the adjusting screw after the adjustment has been made.

(4) Hydraulic fluid enters the pump through an inlet port. Passages in the yoke carry the fluid to the valve plate, which ports the fluid to the cylinder block. The nine pistons in the cylinder block are actuated by the rotating driven shaft, thereby pressurizing the fluid. From the cylinder block, the fluid is routed to the outlet port of the yoke and then to the pump pressure lines. The pressure control regulator is actuated by pump output pressure that is bled to the regulator. The regulator meters the pressure to the yoke control piston, which positions the yoke.

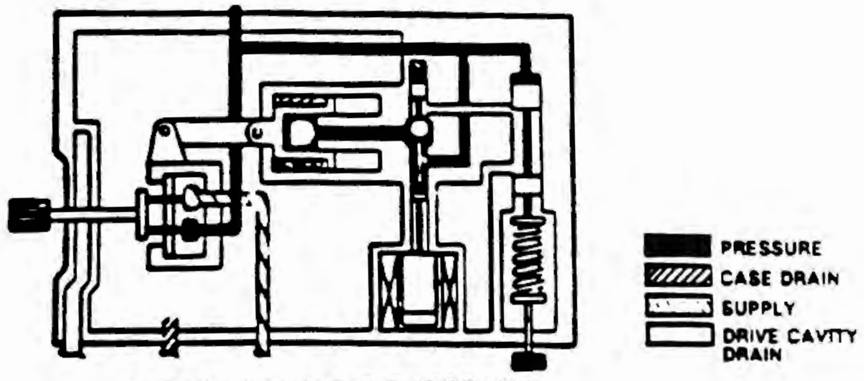
(5) The maximum pump pressure is determined by the adjustment of the pressure control regulator. The pressure control regulator allows maximum output flow (22.5 gpm at 3500 rpm) up to 2850 psi system pressure. When this pressure is reached, the yoke assembly starts to move towards the zero flow position.



MAXIMUM FLOW



COMPENSATOR AT CUTOFF
(MINIMUM FLOW, MAXIMUM PRESSURE)

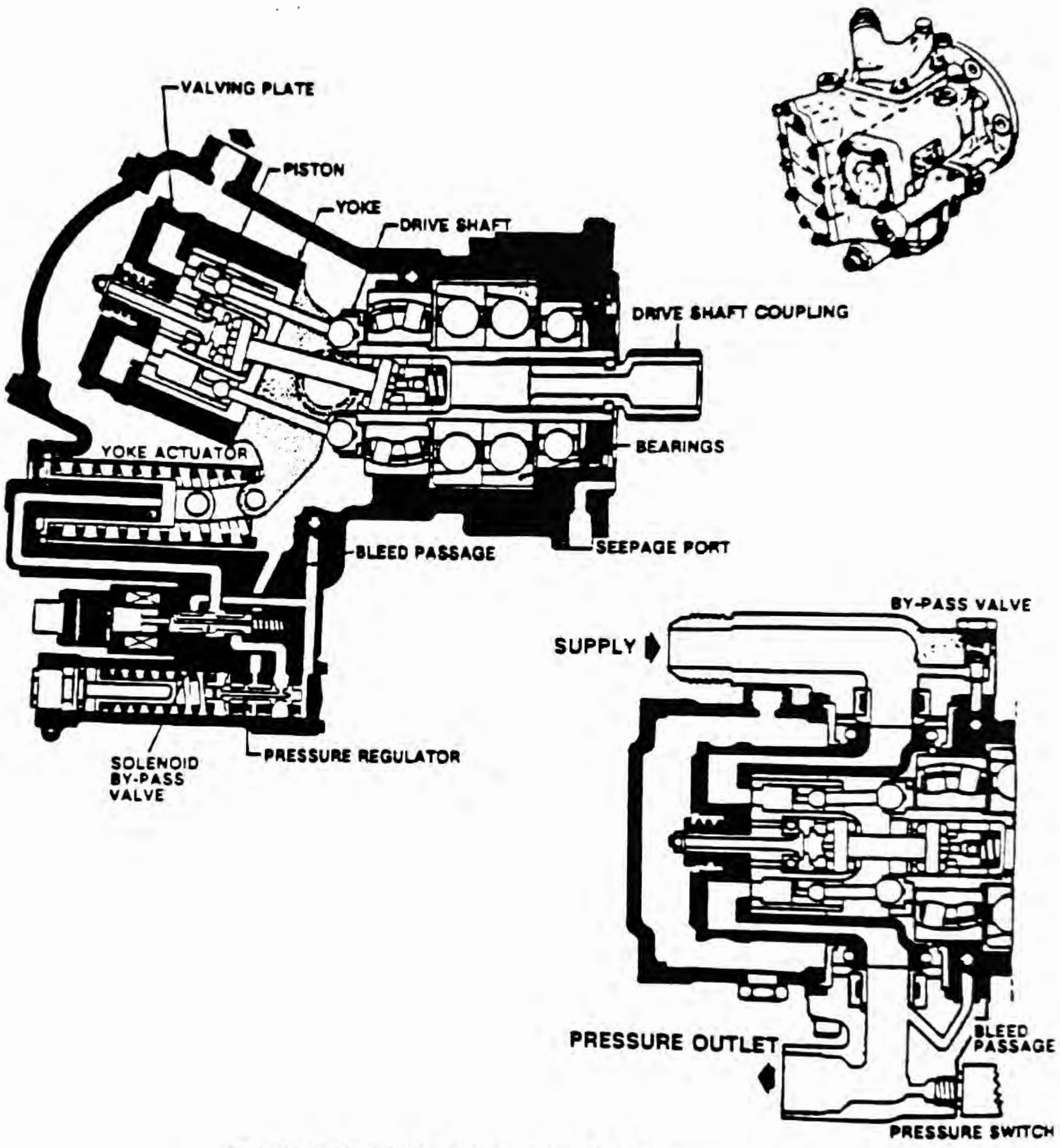


BYPASS SOLENOID ENERGIZED
(300 PSI PRESSURE)

ENGINE-DRIVEN HYDRAULIC PUMP
PRESSURE FLOW SCHEMATIC

FTX80073

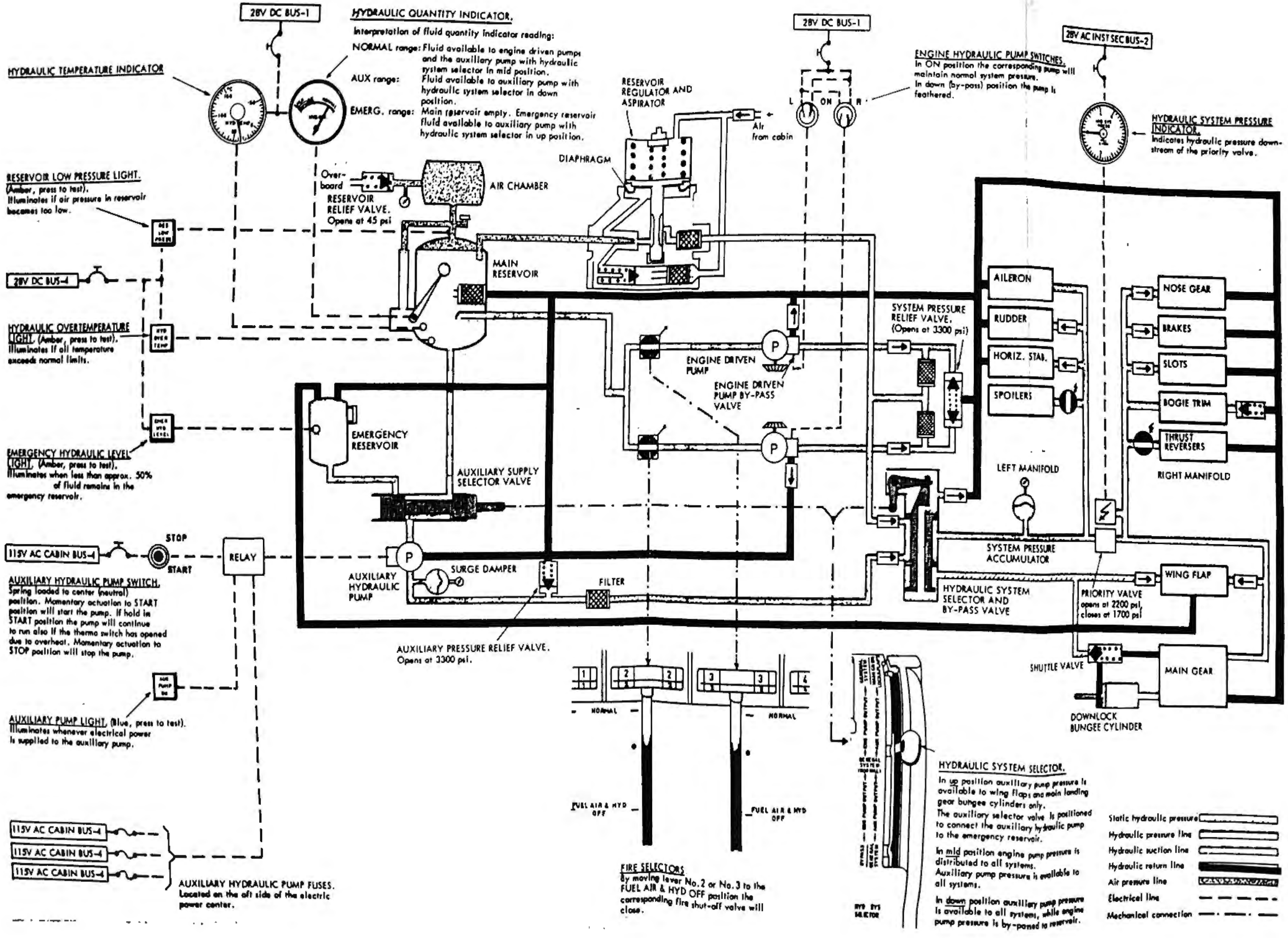
Figure 29-43



ENGINE DRIVEN PUMP CUTAWAY VIEW

FTX80074

Figure 29-44



HYDRAULIC QUANTITY INDICATOR.

Interpretation of fluid quantity indicator reading:

NORMAL range: Fluid available to engine driven pumps and the auxiliary pump with hydraulic system selector in mid position.

AUX range: Fluid available to auxiliary pump with hydraulic system selector in down position.

EMERG. range: Main reservoir empty. Emergency reservoir fluid available to auxiliary pump with hydraulic system selector in up position.

RESERVOIR LOW PRESSURE LIGHT. (Amber, press to test). Illuminates if air pressure in reservoir becomes too low.

RESERVOIR RELIEF VALVE. Opens at 45 psi

HYDRAULIC OVERTEMPERATURE LIGHT. (Amber, press to test). Illuminates if oil temperature exceeds normal limits.

EMERGENCY HYDRAULIC LEVEL LIGHT. (Amber, press to test). Illuminates when less than approx. 50% of fluid remains in the emergency reservoir.

AUXILIARY HYDRAULIC PUMP SWITCH. Spring loaded to center (neutral) position. Momentary actuation to START position will start the pump. If hold in START position the pump will continue to run also if the thermo switch has opened due to overheat. Momentary actuation to STOP position will stop the pump.

AUXILIARY PUMP LIGHT. (Blue, press to test). Illuminates whenever electrical power is supplied to the auxiliary pump.

AUXILIARY HYDRAULIC PUMP FUSES. Located on the aft side of the electric power center.

AUXILIARY PRESSURE RELIEF VALVE. Opens at 3300 psi.

ENGINE HYDRAULIC PUMP SWITCHES. In ON position the corresponding pump will maintain normal system pressure. In down (by-pass) position the pump is feathered.

HYDRAULIC SYSTEM PRESSURE INDICATOR. Indicates hydraulic pressure downstream of the priority valve.

FIRE SELECTORS By moving lever No. 2 or No. 3 to the FUEL AIR & HYD OFF position the corresponding fire shut-off valve will close.

HYDRAULIC SYSTEM SELECTOR.

In up position auxiliary pump pressure is available to wing flaps and main landing gear bungee cylinders only. The auxiliary selector valve is positioned to connect the auxiliary hydraulic pump to the emergency reservoir.

In mid position engine pump pressure is distributed to all systems. Auxiliary pump pressure is available to all systems.

In down position auxiliary pump pressure is available to all systems, while engine pump pressure is by-passed to reservoir.

Static hydraulic pressure
Hydraulic pressure line
Hydraulic suction line
Hydraulic return line
Air pressure line
Electrical line — — — — -
Mechanical connection —· —· —

1. General - Description and Operation

A. Description

(1) This chapter covers the lighting systems and components of the aircraft. Description and operation text is supported by schematic diagrams, and maintenance procedure text is supported by illustrations to assist the mechanic during maintenance.

(2) The major lighting systems are: flight compartment lights, cargo compartment lights, cargo and service compartment lights, exterior lights and emergency lights.

(3) The flight compartment lights consist of instrument and control panel lights, crew utility and work lights, general area lights, and master warning system lights. The lighting systems contain various combinations of red and white incandescent and fluorescent lights.

(4) The cargo compartment lights consist of direct incandescent lighting comprising cabin area lights, entrance lights, service lights and crew work lights.

(5) The cargo and service compartment lights consist of incandescent service lights and spotlights which provide lighting of the cabin compressor and air conditioning compartments, cargo and accessory compartments, and wheel well areas to facilitate cargo loading, area inspection and aircraft maintenance.

(6) The exterior lights consist of high intensity landing and taxi lights, navigation lights, anti-collision lights, wing floodlights for inspection of icing conditions, and ground floodlights to assist aircraft servicing.

(7) The emergency lighting system contains a separate power source and lighting circuits which operate in the event of partial or total power loss in the main lighting system. Emergency lighting equipment consists of rechargeable batteries, automatic switch-over circuits interlocked to the main lighting system, and the emergency light circuits.

(8) The light circuits normally require minor maintenance such as replacement of lamps and switches. Most light assemblies and components are readily accessible and can be maintained without special tools.

(9) The general maintenance practices section of the Maintenance Manual contains standard instructions for removal and installation of components for which detailed procedures are not provided. For relatively simple components using standard attachments, the removal/installation procedure is considered obvious, and individual coverage is not provided. Removal/installation procedures are identical for most switches, relays, and transformers. For examples of these components, see Maintenance Practices.

(10) Some light circuits use electrical connectors, but most of the light assemblies have terminal and screw connections. Where environmental conditions permit, wiring is run in open bundles for easy access. Conduit is used in those areas required by environmental conditions and where maintenance requirement is minimal.

(11) When defective lamps, light assemblies, and components are replaced, equipment with identical part numbers should be installed unless other substitutes have been authorized. Perform functional tests after part replacement to verify proper operation.

(12) Trouble shooting procedures are provided only in the general maintenance practices section. Trouble analysis for most light circuits is performed using identical isolation procedures. In most cases, the prime cause of circuit functional failure is obvious.

(13) The safety precautions that must be observed when performing maintenance of light circuits are outlined in general maintenance practices.

2. Flight Compartment - Description and Operation

A. General (See Figure 33-1)

(1) The flight compartment lights consist of instrument and control panel lights, miscellaneous and work lights, general area lights, and master warning system lights. Flight compartment lighting contains both fluorescent and incandescent lighting in which many lights have both white and red lamps. Most lights have separate, variable controls to

turn on the lights and select brightness level desired. Most of the controls are located on light control panels, although some controls are adjacent to or on the light fixtures. Some lights have permanent or adjustable colored filters.

(2) Most instrument and control panels are integrally lighted by edge lighting lamps in plastic panels surrounding the instrument and control or group of instruments and controls. Separate controls are provided for most major instrument and control panels.

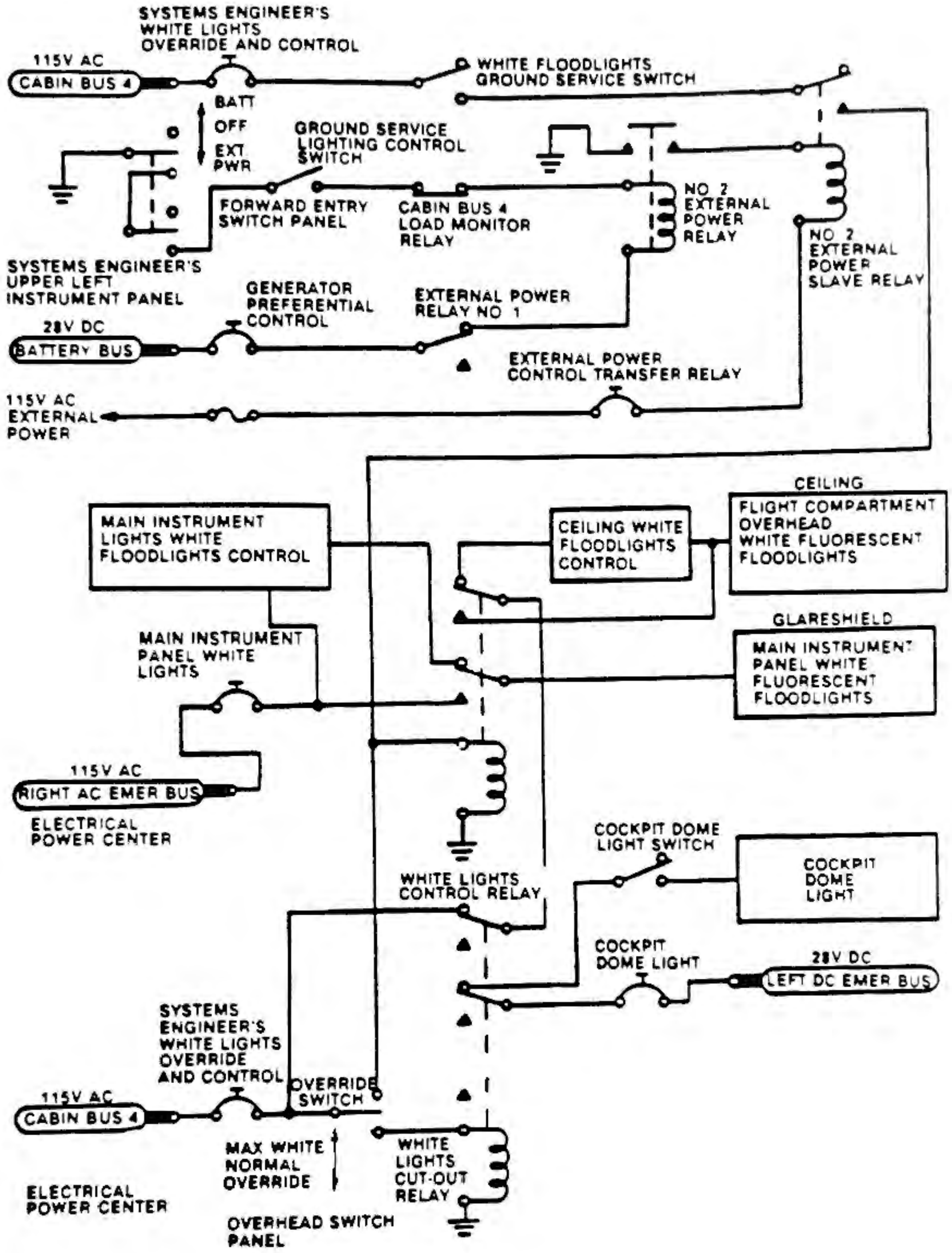
(3) Fluorescent floodlights provide supplementary instrument and control panel area lighting. Incandescent background fill lights provide additional lighting for the instrument and control panels.

(4) Miscellaneous and work lights consist primarily of incandescent work-area lights for the crew members, and general floor or equipment lighting. Incandescent emergency lamps provide general area lighting in the event of loss of normal lighting power.

(5) Master warning system lights provide visual indications of aircraft systems operation and malfunction.

(6) Some of the fluorescent floodlights, the incandescent floodlights, and the instrument and control panel lights provide white lighting, and/or red lighting for night operations. Generally, light controls are separate for the white and red lights. A white light override circuit is provided that permits immediate selection of maximum white light brightness from the ceiling and glareshield fluorescent lights, or immediate cutout of the ceiling white fluorescent lights and other flight compartment white lights. An override switch, located on the overhead switch panel, has three positions: NOR position, the override circuit is inactive and the various lights are controlled by their separate switches. When the switch is placed in the MAX WHITE position, a white light control relay is actuated to apply power directly to the ceiling and glareshield white fluorescent lights for maximum brightness. The individual light controls are bypassed. When the switch is placed in the OVERRIDE position, a white light cutout relay is actuated to turn off the ceiling white fluorescent lights and the cockpit dome light. The red lamps in the ceiling light remain operable for night operations when the override circuit has been actuated. Ground service control switches on the Radio Rack and the forward entry switch panel are used to turn on the ceiling and glareshield white fluorescent lights at

full brightness when external power is applied and the systems engineer's power control switch is set to OFF position. Ground service light control operates the same white light control relay as the override switch.


SYSTEMS ENGINEER'S WHITE LIGHTS OVERRIDE AND CONTROL
115V AC
CABIN BUS 4
WHITE FLOODLIGHTS GROUND SERVICE SWITCH
BATT
OFF
EXT PWR
GROUND SERVICE LIGHTING CONTROL SWITCH
FORWARD ENTRY SWITCH PANEL
CABIN BUS 4 LOAD MONITOR RELAY
NO 2 EXTERNAL POWER RELAY
NO 2 EXTERNAL POWER SLAVE RELAY
SYSTEMS ENGINEER'S UPPER LEFT INSTRUMENT PANEL
GENERATOR PREFERENTIAL CONTROL
EXTERNAL POWER RELAY NO 1
28V DC
BATTERY BUS
EXTERNAL POWER CONTROL TRANSFER RELAY
115V AC EXTERNAL POWER
CEILING
MAIN INSTRUMENT LIGHTS WHITE FLOODLIGHTS CONTROL
CEILING WHITE FLOODLIGHTS CONTROL
FLIGHT COMPARTMENT OVERHEAD WHITE FLUORESCENT FLOODLIGHTS
GLARESHIELD
MAIN INSTRUMENT PANEL WHITE LIGHTS
MAIN INSTRUMENT PANEL WHITE FLUORESCENT FLOODLIGHTS
115V AC
RIGHT AC EMER BUS
ELECTRICAL POWER CENTER
COCKPIT DOME LIGHT SWITCH
COCKPIT DOME LIGHT
WHITE LIGHTS CONTROL RELAY
COCKPIT DOME LIGHT
28V DC
LEFT DC EMER BUS
SYSTEMS ENGINEER'S WHITE LIGHTS OVERRIDE AND CONTROL
OVERRIDE SWITCH
115V AC
CABIN BUS 4
MAX WHITE
NORMAL
OVERRIDE
WHITE LIGHTS CUT-OUT RELAY
ELECTRICAL POWER CENTER
OVERHEAD SWITCH PANEL

WHITE LIGHT OVERRIDE AND GROUND SERVICE LIGHT CONTROL

FTX80198

Figure 33-1

3. Incandescent Floodlights - Description and Operation

A. General (See Figure 33-2)

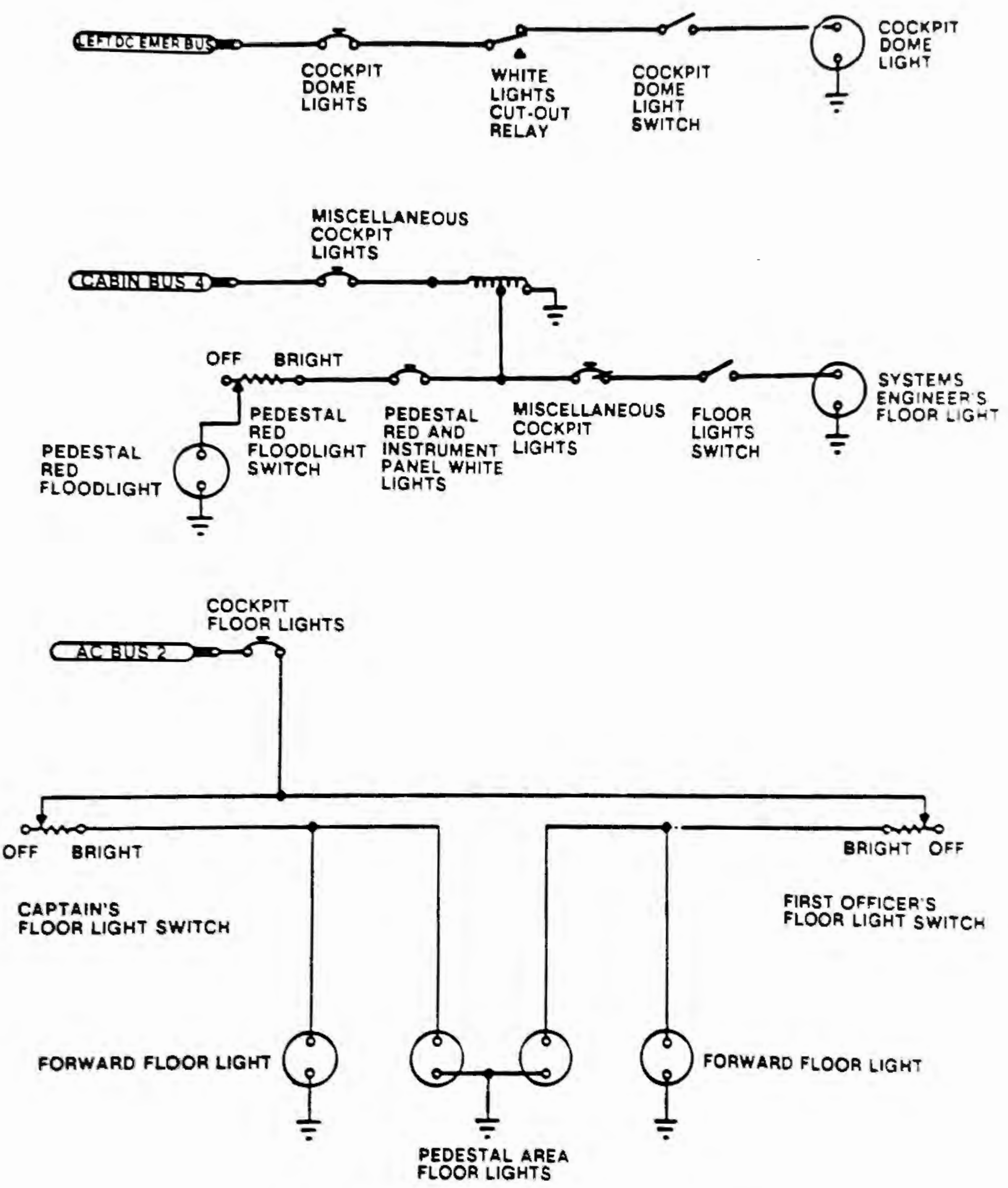
(1) The incandescent lights consist of the cockpit dome light, area floor lights, the captain's, the first officer's, and the systems engineer's floor light.

(2) The cockpit dome light is located in the flight compartment ceiling to the right of the entrance door. the cockpit dome light switch is on the overhead switch panel. Electrical power is supplied by the left DC emergency bus. The cockpit dome light is interlocked through a white lights cutout circuit.

(3) The control pedestal red floodlight is located in the flight compartment ceiling to the right of the fire extinguisher panel. Electrical power is supplied from cabin bus 4. The pedestal red floodlight control, located adjacent to the light fixture housing, is adjustable through a continuous range from light-off to maximum brightness.

(4) Floor lights provide illumination for the captain's and first officer's floor sections, and the control pedestal area. Electrical power is supplied form AC bus 2. Captain's and first officer's floor light controls are located above the left-hand and right-hand consoles, respectively.

(5) The systems engineer's floor light is located on the aft face of the system's engineer's control panel. the floor light switch is located on the systems engineer's control panel upper frame. Electrical power is suppled from cabin bus 4.


LEFT DC EMER BUS
COCKPIT DOME LIGHTS
WHITE LIGHTS CUT-OUT RELAY
COCKPIT DOME LIGHT SWITCH
COCKPIT DOME LIGHT
MISCELLANEOUS COCKPIT LIGHTS
CABIN BUS 4
OFF
BRIGHT
PEDESTAL RED FLOODLIGHT SWITCH
PEDESTAL RED AND INSTRUMENT PANEL WHITE LIGHTS
MISCELLANEOUS COCKPIT LIGHTS
FLOOR LIGHTS SWITCH
SYSTEMS ENGINEER'S FLOOR LIGHT
PEDESTAL RED FLOODLIGHT
COCKPIT FLOOR LIGHTS
AC BUS 2
OFF
BRIGHT
BRIGHT
OFF
CAPTAIN'S FLOOR LIGHT SWITCH
FIRST OFFICER'S FLOOR LIGHT SWITCH
FORWARD FLOOR LIGHT
FORWARD FLOOR LIGHT
PEDESTAL AREA FLOOR LIGHTS

INCANDESCENT FLOODLIGHT

FTX80199

Figure 33-2

4. Fluorescent Floodlights - Description and Operation

A. General (See Figures 33-3 & 33-4)

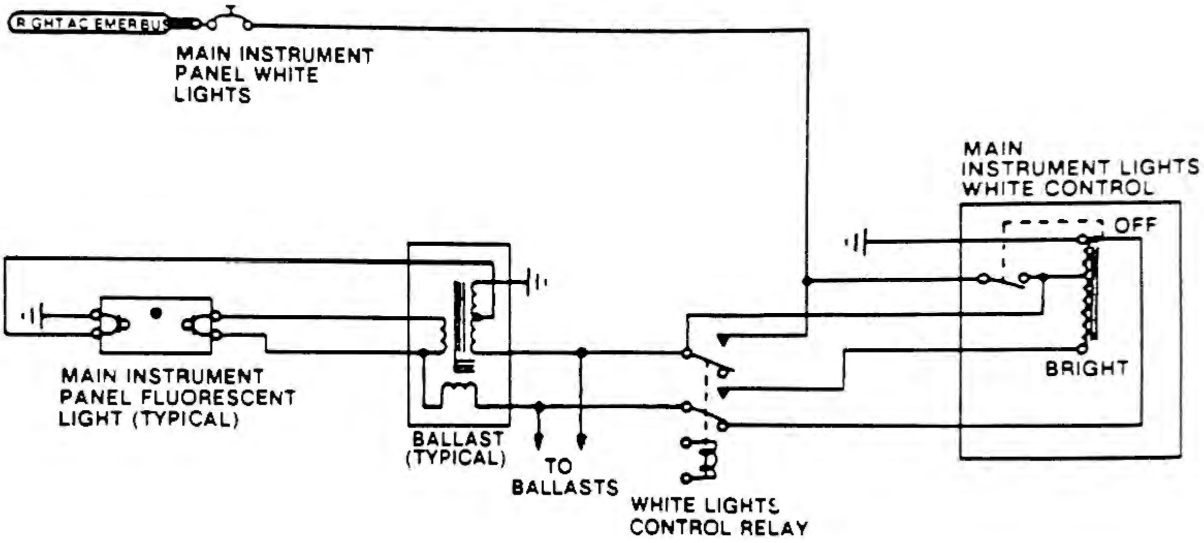
(1) The flight compartment fluorescent floodlights provide general illumination of the main instrument panel, the systems engineer's control panel, and the electrical power center circuit breaker panel.

(2) The main instrument panel fluorescent floodlights, located two to a side under the glareshield, provide general white lighting for the captain's and first officer's flight and engine instrument panels. A main instrument white lights control, on the overhead switch panel, permits normal adjustment of floodlight intensity through a continuous range from lights-off to maximum brightness. Electrical power is supplied by the right ac emergency bus.

(3) The white fluorescent floodlights in the flight compartment ceiling fixture provide general illumination of the systems engineer's control panel. A white floodlight control on the center section of the systems engineer's control panel permits normal adjustment of flood-light intensity through a continuous range from lights-off to maximum brightness. the red fluorescent floodlights in the flight compartment ceiling fixture provide general illumination of the systems engineer's control panel for night operations. A red floodlight control on the center section of the systems engineer's control panel permits adjustment of floodlight intensity through a continuous range from lights-off to maximum brightness. Electrical power is supplied by cabin bus 4, for the white lights, and ac bus 3 for the red lights.

(4) A supplementary control circuit is contained in the white fluorescent light circuits in the form of a white lights override control. The override switch, located on the overhead switch panel, permits immediate selection of maximum white light brightness from the ceiling and glareshield fluorescent lights regardless of the settings of the individual light controls. In addition, the override switch permits immediate cutout of the ceiling white lights and other cockpit white lights during night operations.

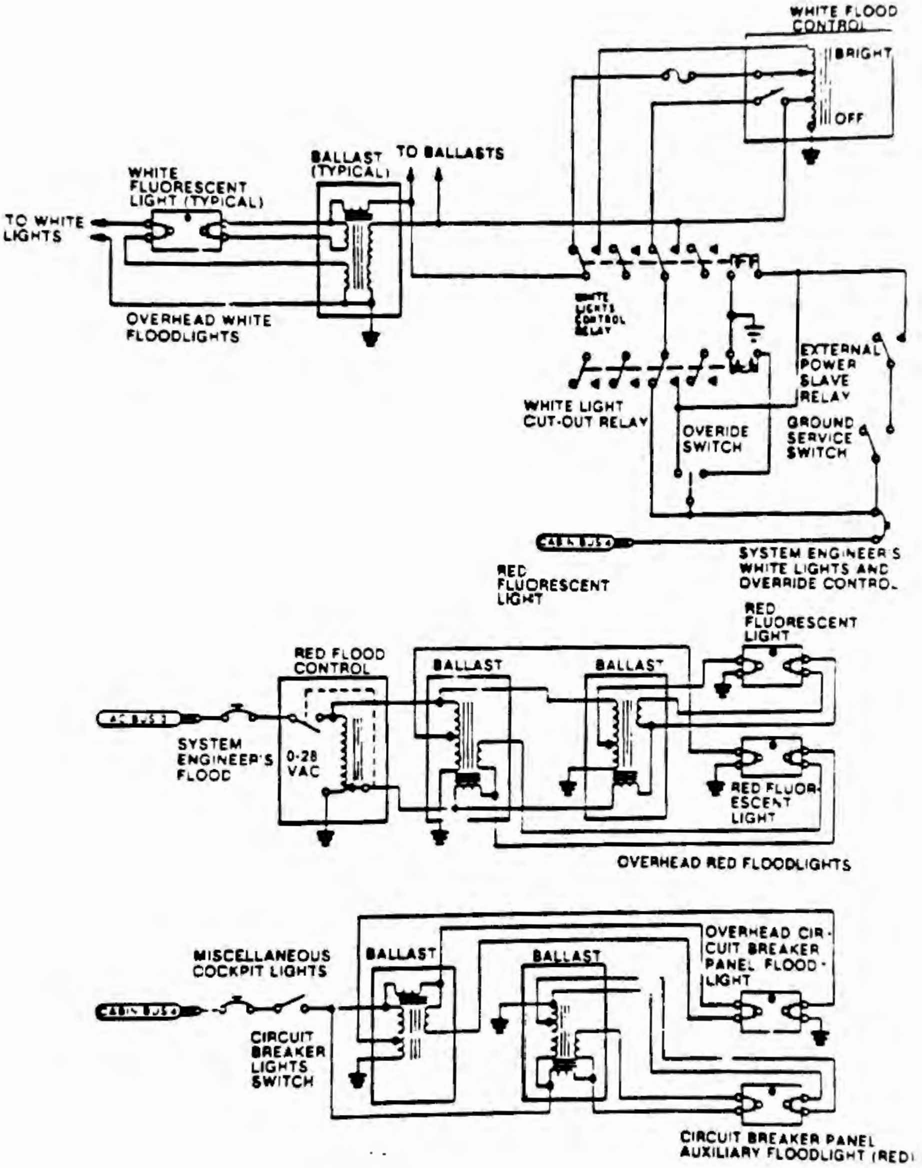
(5) The electrical power center circuit breaker panels are illuminated by a red fluorescent floodlight in the flight compartment ceiling and an auxiliary red floodlight located on the systems engineer's control panel. Both floodlights are controlled by an off-on switch on the upper frame of the systems engineer's control panel. Electrical power is supplied by cabin bus 4.


RIGHT AC EMER BUS
MAIN INSTRUMENT PANEL WHITE LIGHTS
MAIN INSTRUMENT LIGHTS WHITE CONTROL
OFF
BRIGHT
MAIN INSTRUMENT PANEL FLUORESCENT LIGHT (TYPICAL)
BALLAST (TYPICAL)
TO BALLASTS
WHITE LIGHTS CONTROL RELAY

MAIN INSTRUMENT PANEL FLUORESCENT FLOODLIGHTS

FTX80200

Figure 33-3


WHITE FLOOD CONTROL
BRIGHT
OFF
BALLAST (TYPICAL)
TO BALLASTS
WHITE FLUORESCENT LIGHT (TYPICAL)
TO WHITE LIGHTS
OVERHEAD WHITE FLOODLIGHTS
WHITE LIGHTS CONTROL RELAY
EXTERNAL POWER SLAVE RELAY
WHITE LIGHT CUT-OUT RELAY
OVERIDE SWITCH
GROUND SERVICE SWITCH
CABIN BUS
SYSTEM ENGINEER'S WHITE LIGHTS AND OVERRIDE CONTROL
RED FLUORESCENT LIGHT
RED FLUORESCENT LIGHT
RED FLOOD CONTROL
BALLAST
BALLAST
AC BUS 1
SYSTEM ENGINEER'S FLOOD
0-28 VAC
RED FLUORESCENT LIGHT
OVERHEAD RED FLOODLIGHTS
MISCELLANEOUS COCKPIT LIGHTS
BALLAST
BALLAST
OVERHEAD CIRCUIT BREAKER PANEL FLOOD-LIGHT
CABIN BUS
CIRCUIT BREAKER LIGHTS SWITCH
CIRCUIT BREAKER PANEL AUXILIARY FLOODLIGHT (RED)

SYSTEMS ENGINEER'S CONTROL PANEL AND CIRCUIT BREAKER PANEL FLUORESCENT FLOODLIGHTS

FTX80201

Figure 33-4

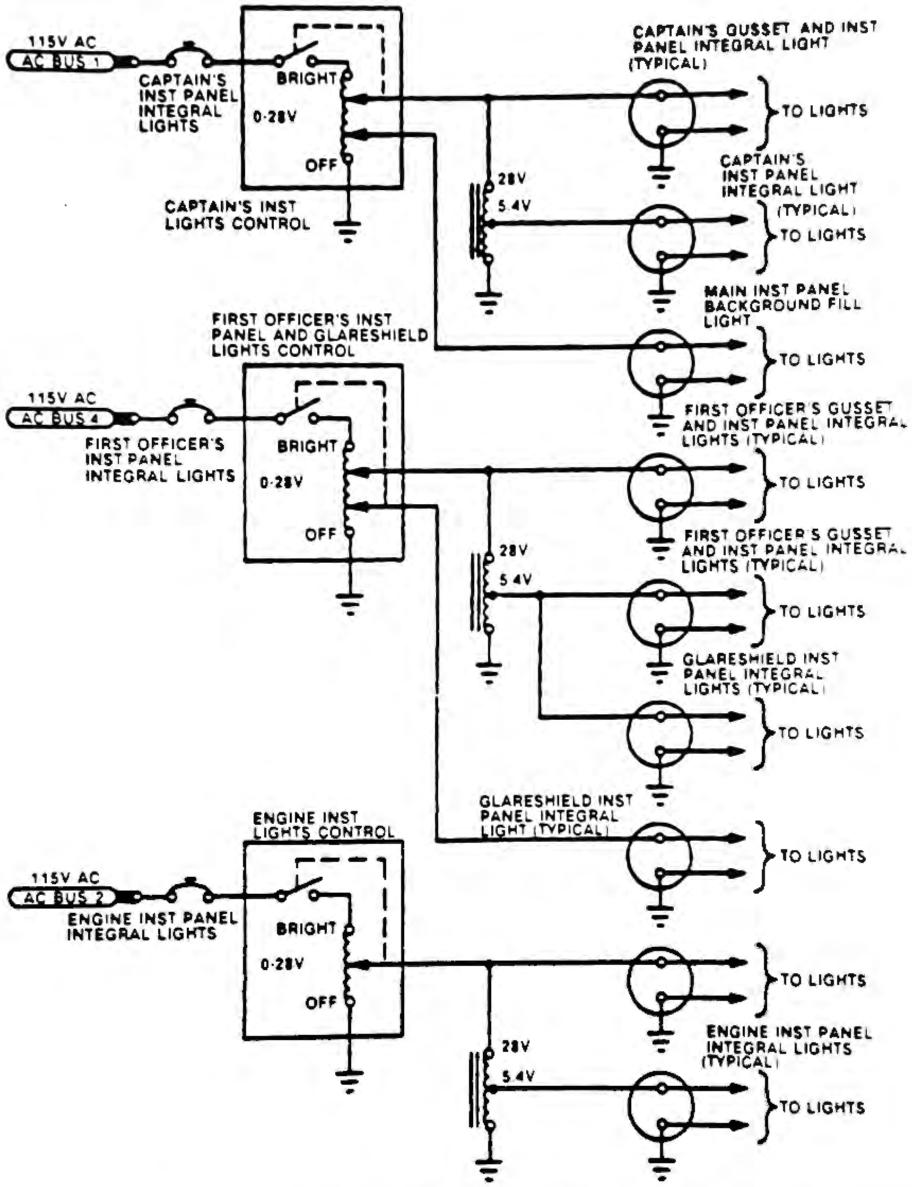
5. Instrument and Control Panel Lights - Description and Operation

A. General (See Figures 33-5, 33-6 & 33-7)

(1) Instrument and control panel lights consist of integral panel lights, and white background fill lights. The integral panel lights illuminate each control and instrument so equipped. The background fill lights provide low-level general lighting for the main instrument panel.

(2) The integral panel lights consist of edge-lighted, translucent panels surrounding the controls and indicators. Control and instrument nomenclature, engraved in the face of the light panel, is lighted by the diffusion of edge lighting within the panel. Integral panel lights are contained on the glareshield, main instrument panel, overhead switch panel, fire panel, pedestal casting and radio panels, systems engineer's panel, and the captain's and first officer's gusset panels. The captain's and first officer's flight instrument panels, the engine instrument panel, pedestal, and overhead switch panel integral panel lights have individual controls on the overhead switch panel. The systems engineer's instrument lights are controlled by an instrument lights control on the center section panel. All integral lighting controls are variable through a continuous range from lights-off to maximum brightness. Electrical power for the integral lights is supplied by AC bus 1, AC bus 2, AC bus 3, and AC bus 4.

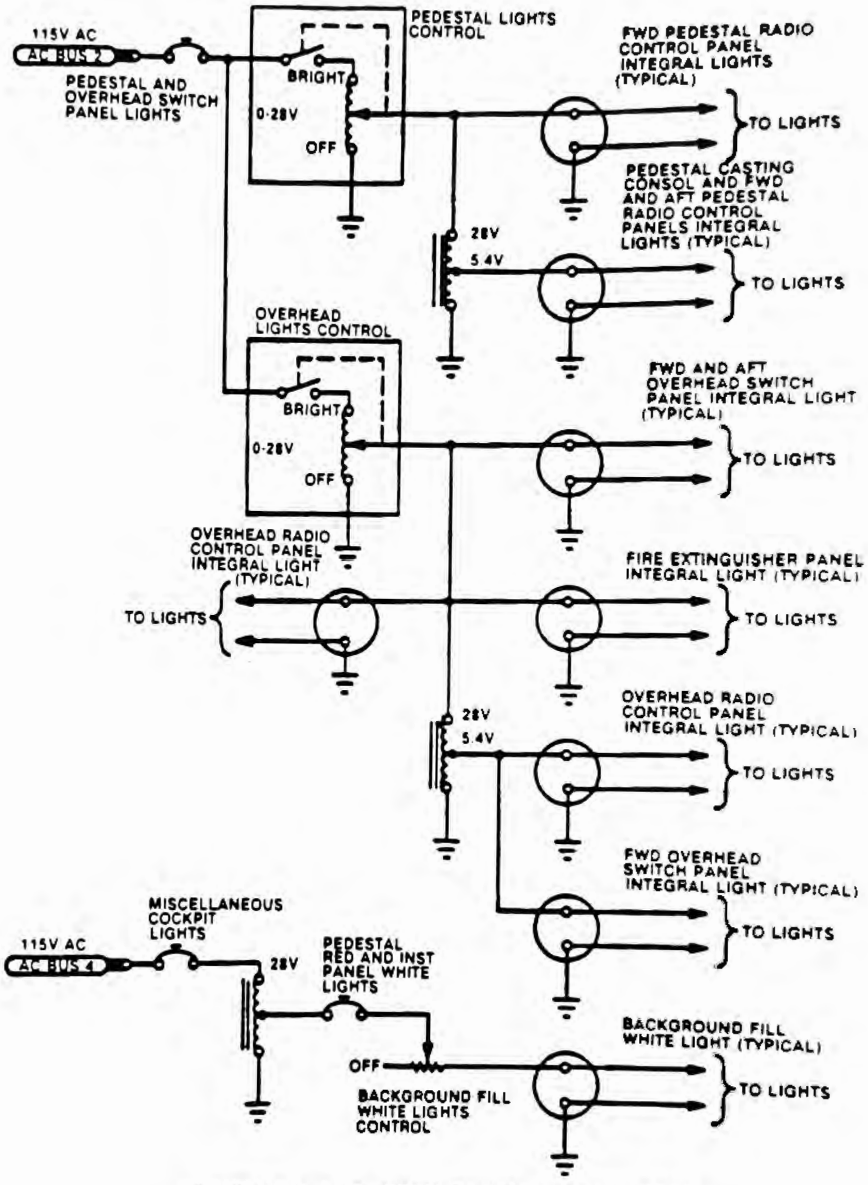
(3) The background fill white lights, located under the glareshield, provide low-level white lighting for the main instrument panel. background fill white lights control, on the glareshield, is variable through a continuous range from lights-off to maximum brightness. Electrical power is supplied by cabin bus 4.


115V AC
AC BUS 1
CAPTAIN'S INST PANEL INTEGRAL LIGHTS
BRIGHT
0-28V
OFF
CAPTAIN'S INST LIGHTS CONTROL
28V
5.4V
CAPTAIN'S GUSSET AND INST PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
CAPTAIN'S INST PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
MAIN INST PANEL BACKGROUND FILL LIGHT
TO LIGHTS
FIRST OFFICER'S INST PANEL AND GLARESHIELD LIGHTS CONTROL
115V AC
AC BUS 4
FIRST OFFICER'S INST PANEL INTEGRAL LIGHTS
BRIGHT
0-28V
OFF
FIRST OFFICER'S GUSSET AND INST PANEL INTEGRAL LIGHTS (TYPICAL)
TO LIGHTS
28V
5.4V
FIRST OFFICER'S GUSSET AND INST PANEL INTEGRAL LIGHTS (TYPICAL)
TO LIGHTS
GLARESHIELD INST PANEL INTEGRAL LIGHTS (TYPICAL)
TO LIGHTS
ENGINE INST LIGHTS CONTROL
GLARESHIELD INST PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
115V AC
AC BUS 2
ENGINE INST PANEL INTEGRAL LIGHTS
BRIGHT
0-28V
OFF
TO LIGHTS
28V
5.4V
ENGINE INST PANEL INTEGRAL LIGHTS (TYPICAL)
TO LIGHTS

CAPTAIN'S AND FIRST OFFICER'S MAIN INSTRUMENT PANEL LIGHTS

FTX80202

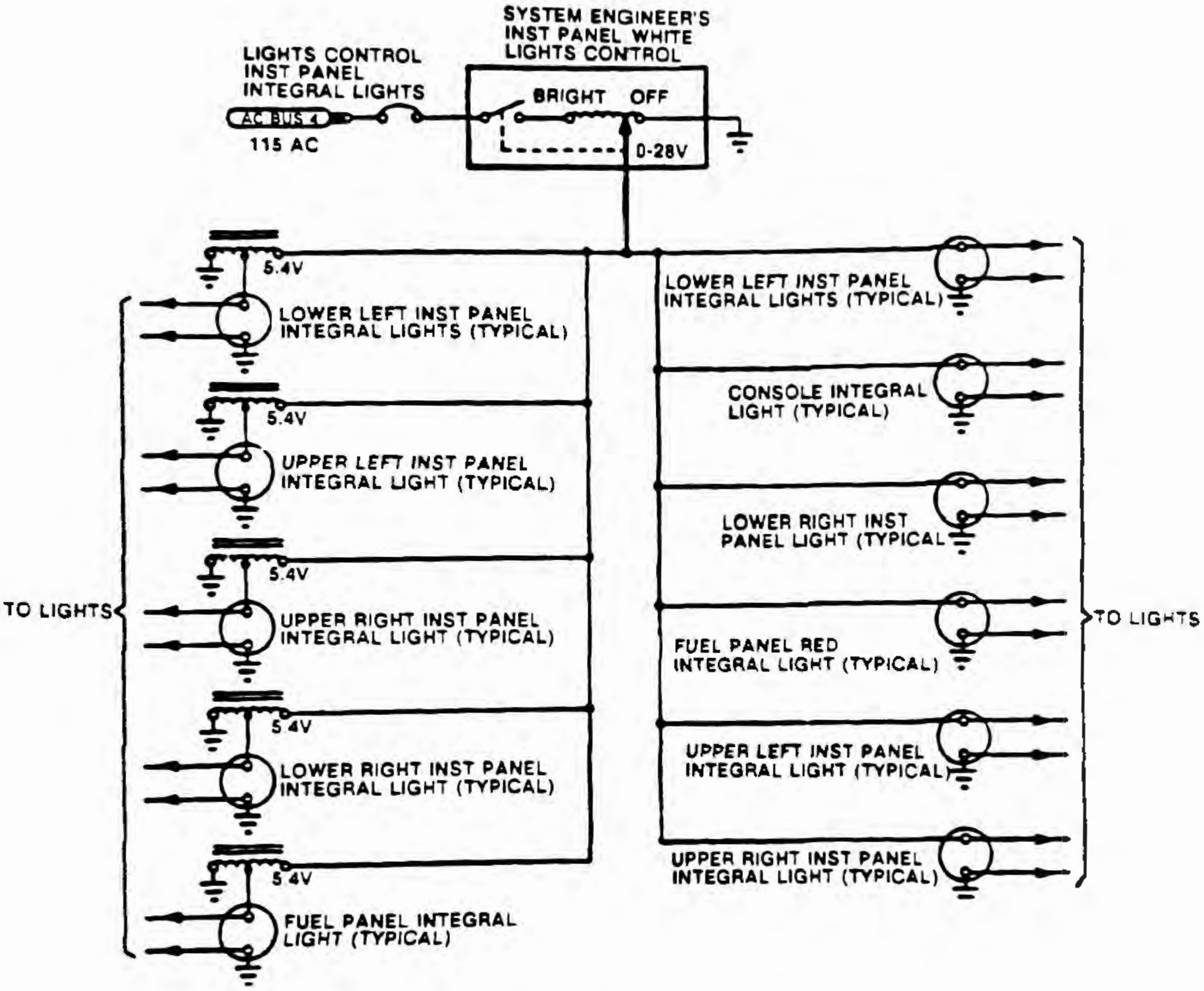
Figure 33-5


115V AC
AC BUS 2
PEDESTAL AND OVERHEAD SWITCH PANEL LIGHTS
PEDESTAL LIGHTS CONTROL
BRIGHT
0-28V
OFF
FWD PEDESTAL RADIO CONTROL PANEL INTEGRAL LIGHTS (TYPICAL)
TO LIGHTS
PEDESTAL CASTING CONSOL AND FWD AND AFT PEDESTAL RADIO CONTROL PANELS INTEGRAL LIGHTS (TYPICAL)
28V
5.4V
TO LIGHTS
OVERHEAD LIGHTS CONTROL
BRIGHT
0-28V
OFF
FWD AND AFT OVERHEAD SWITCH PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
OVERHEAD RADIO CONTROL PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
FIRE EXTINGUISHER PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
28V
5.4V
OVERHEAD RADIO CONTROL PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
FWD OVERHEAD SWITCH PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
MISCELLANEOUS COCKPIT LIGHTS
115V AC
AC BUS 4
28V
PEDESTAL RED AND INST PANEL WHITE LIGHTS
BACKGROUND FILL WHITE LIGHT (TYPICAL)
OFF
BACKGROUND FILL WHITE LIGHTS CONTROL
TO LIGHTS

CAPTAIN'S AND FIRST OFFICER'S PEDESTAL AND OVERHEAD SWITCH PANEL LIGHTS

FTX80203

Figure 33-6


SYSTEM ENGINEER'S INST PANEL WHITE LIGHTS CONTROL
LIGHTS CONTROL INST PANEL INTEGRAL LIGHTS
AC BUS 4
115 AC
BRIGHT
OFF
0-28V
5.4V
LOWER LEFT INST PANEL INTEGRAL LIGHTS (TYPICAL)
5.4V
UPPER LEFT INST PANEL INTEGRAL LIGHT (TYPICAL)
5.4V
UPPER RIGHT INST PANEL INTEGRAL LIGHT (TYPICAL)
5.4V
LOWER RIGHT INST PANEL INTEGRAL LIGHT (TYPICAL)
5.4V
FUEL PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS
LOWER LEFT INST PANEL INTEGRAL LIGHTS (TYPICAL)
CONSOLE INTEGRAL LIGHT (TYPICAL)
LOWER RIGHT INST PANEL LIGHT (TYPICAL
FUEL PANEL RED INTEGRAL LIGHT (TYPICAL)
UPPER LEFT INST PANEL INTEGRAL LIGHT (TYPICAL)
UPPER RIGHT INST PANEL INTEGRAL LIGHT (TYPICAL)
TO LIGHTS

SYSTEMS ENGINEER'S CONTROL PANEL LIGHTS

FTX80204

Figure 33-7

6. Miscellaneous and Work Lights - Description and Operation (See Figure 33-8)

A. General

(1) The miscellaneous and work lights consist of captain's and first officer's map, briefcase, and chartholder lights; systems engineer's work table lights, observer's map light, and electrical power center work lights.

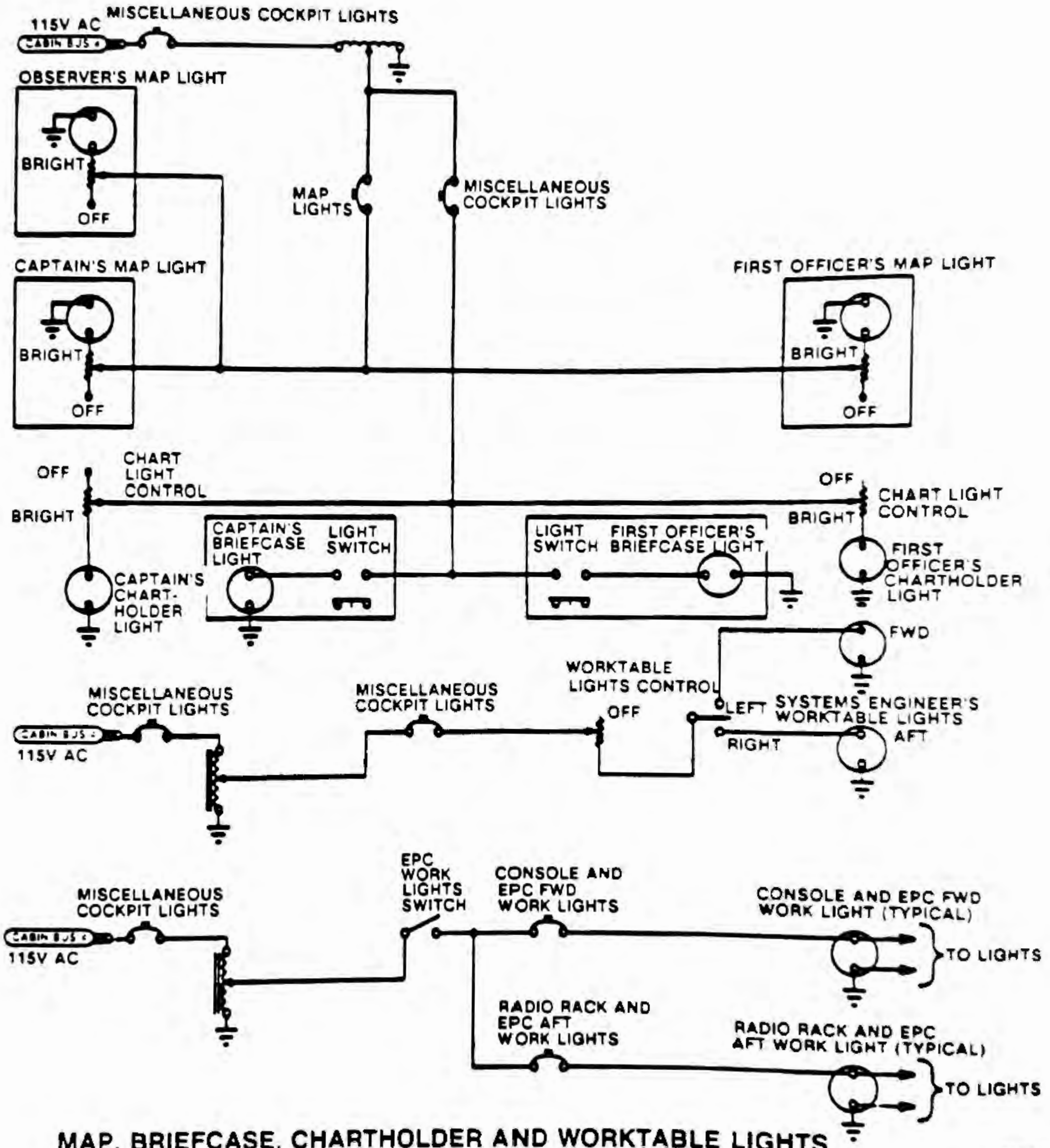
(2) The captain's and first officer's map lights are located in the flight compartment ceiling on the left and right sides of the overhead switch panel, respectively. The observer's map light is located in the flight compartment port ceiling above the observer's station. Electrical power is supplied by cabin bus 4. Map light controls, located adjacent to the individual lights, are adjustable through a continuous range from lights-off to maximum brightness. Each light has an adjustable red filter which may be rotated into position for night operation.

(3) The captain's and first officer's briefcase lights are located above the left-hand and right-hand consoles, respectively. Push-on/push-off switches are located on the individual light fixtures. Electrical power is supplied by cabin bus 4. Red filters are permanently installed in the lights.

(4) The captain's and first officer's chartholder lights are located above the left-hand and right-hand consoles, respectively. Light controls, located adjacent to the individual lights, are variable through a continuous range from lights-off to maximum brightness. Electrical power is supplied by cabin bus 4.

(5) The systems engineer's forward worktable light is located in the flight compartment ceiling just forward of the systems engineer's station. The aft worktable light is mounted on the aft edge of the systems engineer's control panel. The 2-position switch, on the systems engineer's control panel permits selection of either light. The variable light control, on the control panel, is adjustable through a continuous range from lights-off to maximum brightness. Electrical power is supplied by cabin bus 4. Each light has a red filter which may be rotated into position for night operation.

(6) The electrical power center work lights, located behind access doors, provide lighting to facilitate maintenance activities. The work lights are located in the left and right consoles, the generator bus bay and control rack, the flight compartment entrance door ceiling area, the upper radio rack area, the equipment panels, and the systems engineer's worktable area. All the work lights are controlled by a single switch on the aft center equipment panel. Electrical power is supplied by cabin bus 4.


115V AC
MISCELLANEOUS COCKPIT LIGHTS
CABIN BUS
OBSERVER'S MAP LIGHT
BRIGHT
OFF
MAP LIGHTS
MISCELLANEOUS COCKPIT LIGHTS
CAPTAIN'S MAP LIGHT
BRIGHT
OFF
FIRST OFFICER'S MAP LIGHT
BRIGHT
OFF
OFF
CHART LIGHT CONTROL
BRIGHT
OFF
CHART LIGHT CONTROL
BRIGHT
CAPTAIN'S BRIEFCASE LIGHT
LIGHT SWITCH
LIGHT SWITCH
FIRST OFFICER'S BRIEFCASE LIGHT
CAPTAIN'S CHART-HOLDER LIGHT
FIRST OFFICER'S CHARTHOLDER LIGHT
FWD
WORKTABLE LIGHTS CONTROL
MISCELLANEOUS COCKPIT LIGHTS
MISCELLANEOUS COCKPIT LIGHTS
CABIN BUS
115V AC
OFF
LEFT
RIGHT
SYSTEMS ENGINEER'S WORKTABLE LIGHTS
AFT
EPC WORK LIGHTS SWITCH
CONSOLE AND EPC FWD WORK LIGHTS
MISCELLANEOUS COCKPIT LIGHTS
CABIN BUS
115V AC
CONSOLE AND EPC FWD WORK LIGHT (TYPICAL)
TO LIGHTS
RADIO RACK AND EPC AFT WORK LIGHTS
RADIO RACK AND EPC AFT WORK LIGHT (TYPICAL)
TO LIGHTS

MAP, BRIEFCASE, CHARTHOLDER AND WORKTABLE LIGHTS

FTX80205

Figure 33-8

7. Master Warning Lights - Description and Operation

A. General (See Figures 33-9 & 33-10)

(1) The master warning lights system provides the captain and the first officer with a visual indication that a warning light has been lighted outside the periphery of their vision. The two-lamp, master warning light, located on the glareshield, is turned off by pressing the lens cap, which rearms the light circuit to again indicate a warning from a different source than the preceding warning. Warning lights for the individual warning detection circuits remain lighted until the corresponding malfunction or abnormal condition is corrected. Warning detection circuits that will light the master warning light are listed below.

(a) Cabin compressor overheating

(b) Manifold air overtemperature

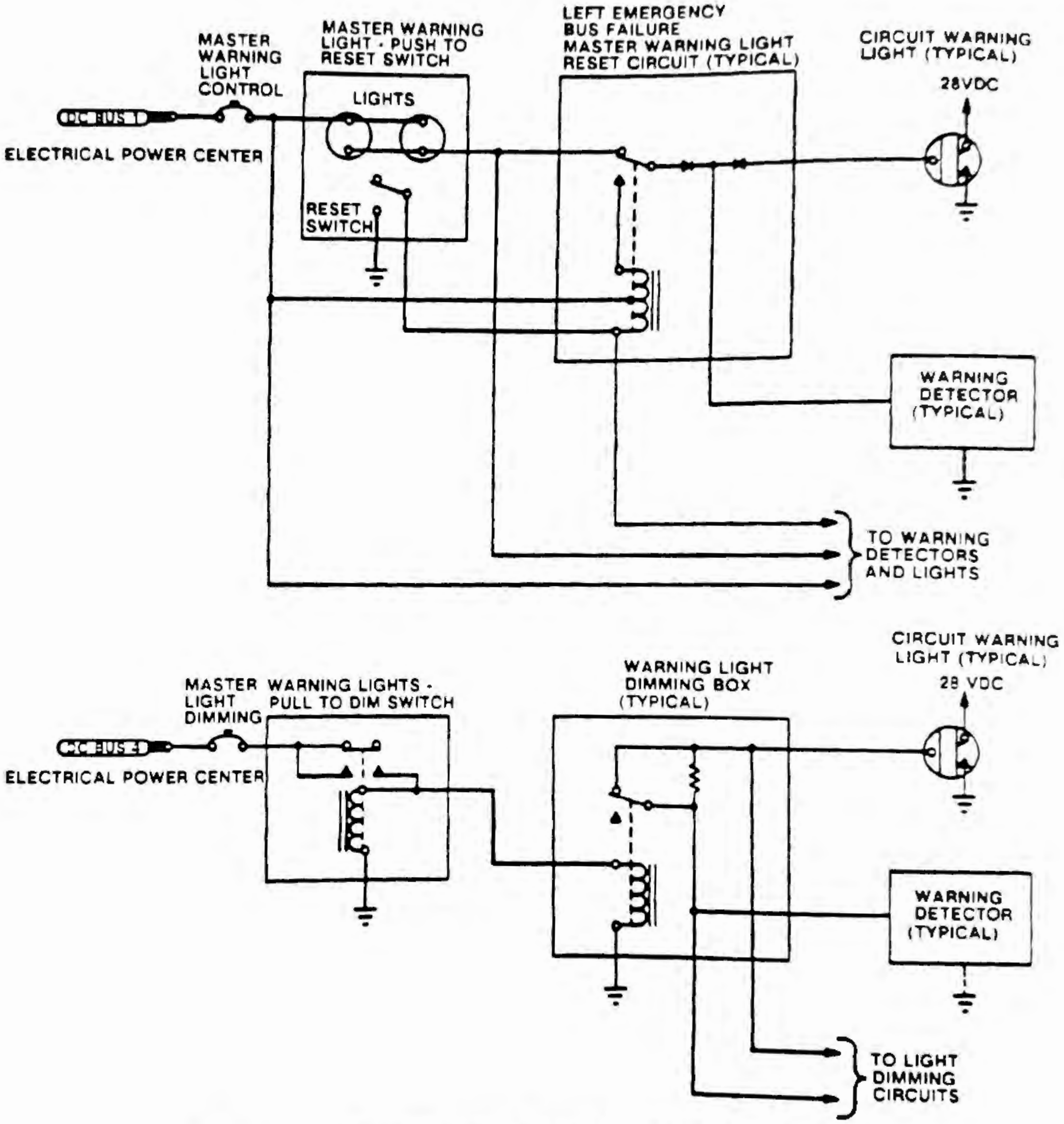
(c) Left or right ac emergency bus failure

(d) Manifold rupture

(e) Cabin doors open

(f) Belly doors open

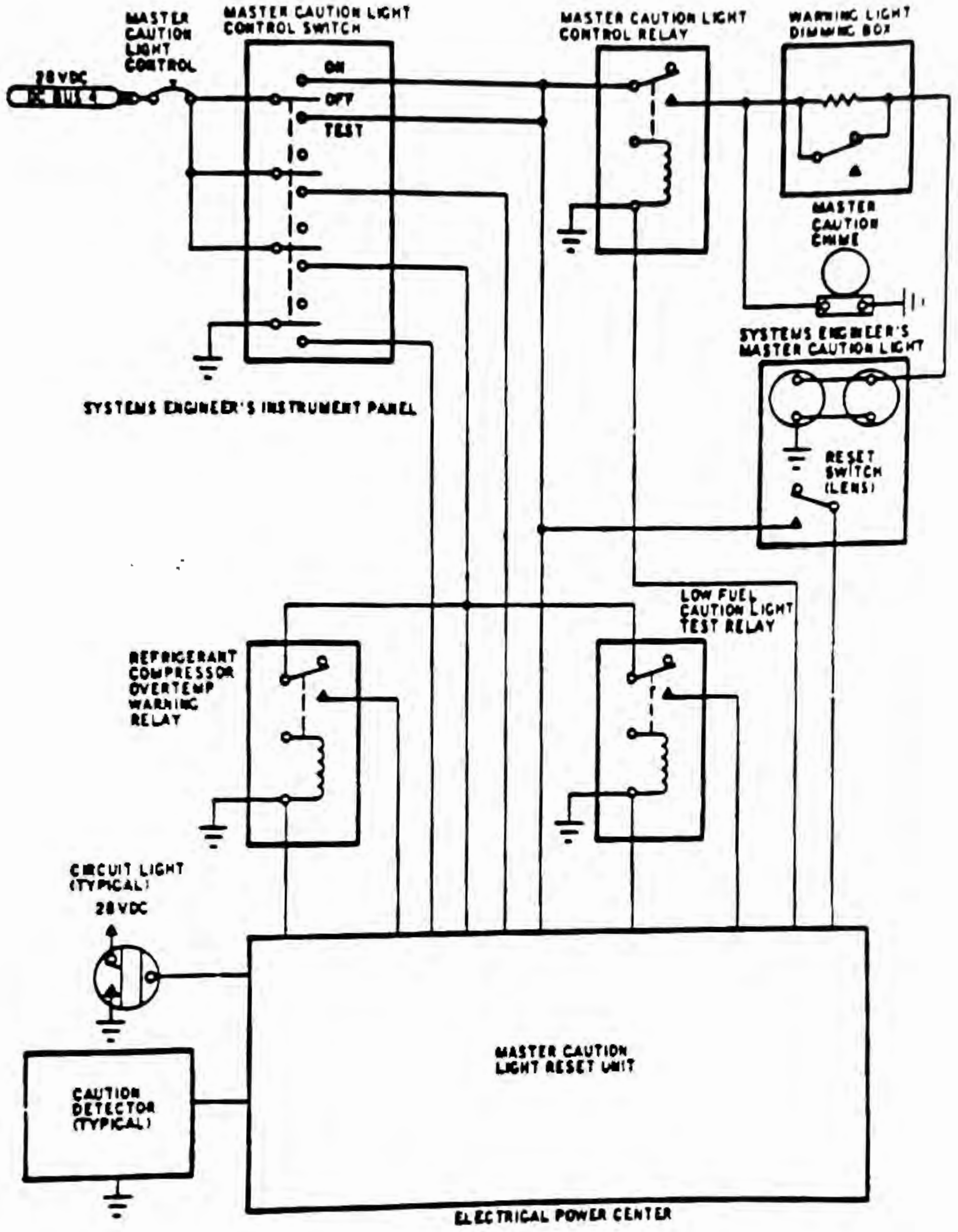
(2) The warning light dimming system permits the captain or first officer to reduce the intensity of warning, caution and advisory indicator lighting. The master WARNING LIGHTS PULL TO DIM switch located on the overhead switch panel, controls dimming boxes in the electrical power center and annunciator dim/test boxes located in the radio rack mixing chamber. The dimming boxes contain relays which switch a voltage-dropping resistor into series with each warning light when the master WARNING LIGHTS PULL TO DIM switch is operated. When aircraft electrical power is turned off, the dimming circuits return to the warning lights bright and annunciator lights bright condition. All warning light circuits listed in paragraph 1A contain dimming circuits except for the master warning light on the glareshield, BELLY DOOR OPEN and CABIN DOOR OPEN annunciators located in center of flight engineer's lower left instrument panel.


MASTER WARNING LIGHT CONTROL
MASTER WARNING LIGHT - PUSH TO RESET SWITCH
LEFT EMERGENCY BUS FAILURE MASTER WARNING LIGHT RESET CIRCUIT (TYPICAL)
CIRCUIT WARNING LIGHT (TYPICAL)
28VDC
DC BUS 1
ELECTRICAL POWER CENTER
LIGHTS
RESET SWITCH
WARNING DETECTOR (TYPICAL)
TO WARNING DETECTORS AND LIGHTS
CIRCUIT WARNING LIGHT (TYPICAL)
28 VDC
WARNING LIGHT DIMMING BOX (TYPICAL)
MASTER LIGHT DIMMING
WARNING LIGHTS - PULL TO DIM SWITCH
DC BUS
ELECTRICAL POWER CENTER
WARNING DETECTOR (TYPICAL)
TO LIGHT DIMMING CIRCUITS

MASTER WARNING LIGHT AND DIMMING CIRCUIT

FTX80206

Figure 33-9


MASTER CAUTION LIGHT CONTROL
MASTER CAUTION LIGHT CONTROL SWITCH
MASTER CAUTION LIGHT CONTROL RELAY
WARNING LIGHT DIMMING BOX
28 VDC
DC BUS 4
ON
OFF
TEST
MASTER CAUTION CHIME
SYSTEMS ENGINEER'S MASTER CAUTION LIGHT
RESET SWITCH (LENS)
SYSTEMS ENGINEER'S INSTRUMENT PANEL
LOW FUEL CAUTION LIGHT TEST RELAY
REFRIGERANT COMPRESSOR OVERTEMP WARNING RELAY
CIRCUIT LIGHT (TYPICAL)
28 VDC
MASTER CAUTION LIGHT RESET UNIT
CAUTION DETECTOR (TYPICAL)
ELECTRICAL POWER CENTER

MASTER CAUTION LIGHT CIRCUIT

FTX80207

Figure 33-10

8. Annunciator System - Description and Operation

A. General

(1) The annunciator system provides the captain, first officer (FO) and flight engineer (FE) with visual warning, caution, and/or advisory indications. Annunciators for the individual detection circuits remain lighted until the corresponding malfunction or abnormal condition is corrected or system function is changed by a crew member such as thrust brake position selector. The annunciator dim/test circuits provide a means of dimming and testing the annunciators associated with annunciator dim/test boxes.

(2) The annunciator dimming circuit permits the captain or first officer to reduce the intensity of warning, caution and advisory indicator lighting. The master WARNING LIGHTS PULL TO DIM switch, located on the overhead switch panel, controls annunciator dim/test boxes, located in the radio rack mixing chamber and dimming boxes located in the electrical power center. The annunciator dim/test boxes contain a relay which switches a bright or dim potentiometer, also located in each annunciator dim/test box, into the annunciator power supply control circuit when the master WARNING LIGHTS PULL TO DIM switch is operated. The annunciator power supply, dependent on control signal inputs, supplies dim or bright power to the annunciator dim/test box for distribution to the annunciators. When aircraft electrical power is turned off, the dimming circuits return to the annunciator lights bright and warning lights bright condition.

(3) The annunciators located on the captain's, first officer's and engine instrument panel may be tested by actuating the LIGHT TEST toggle switch located on the upper main instrument panel, right side. If the LIGHT TEST toggle switch is set to "MOM" (momentary) the annunciators will go on until the switch is released. If the LIGHT TEST toggle switch is set to 'ON" the annunciators will go on, and remain on until the switch is set back to center. When the LIGHT TEST toggle switch is actuated both annunciator test relays will energize. Power and ground is now applied through the annunciator test relay to both annunciator dim/test boxes for distribution to the annunciators located on the captain's first officer's and engine instrument panel.

The annunciators located on the FE instrument panel may be tested by pressing the FE ANNUNC TEST switch, located on the FE upper right control panel. Pressing the FE ANNUNC TEST switch applies ground to the FO annunciator dim/test box for distribution to illuminate the FE control panel annunciators.

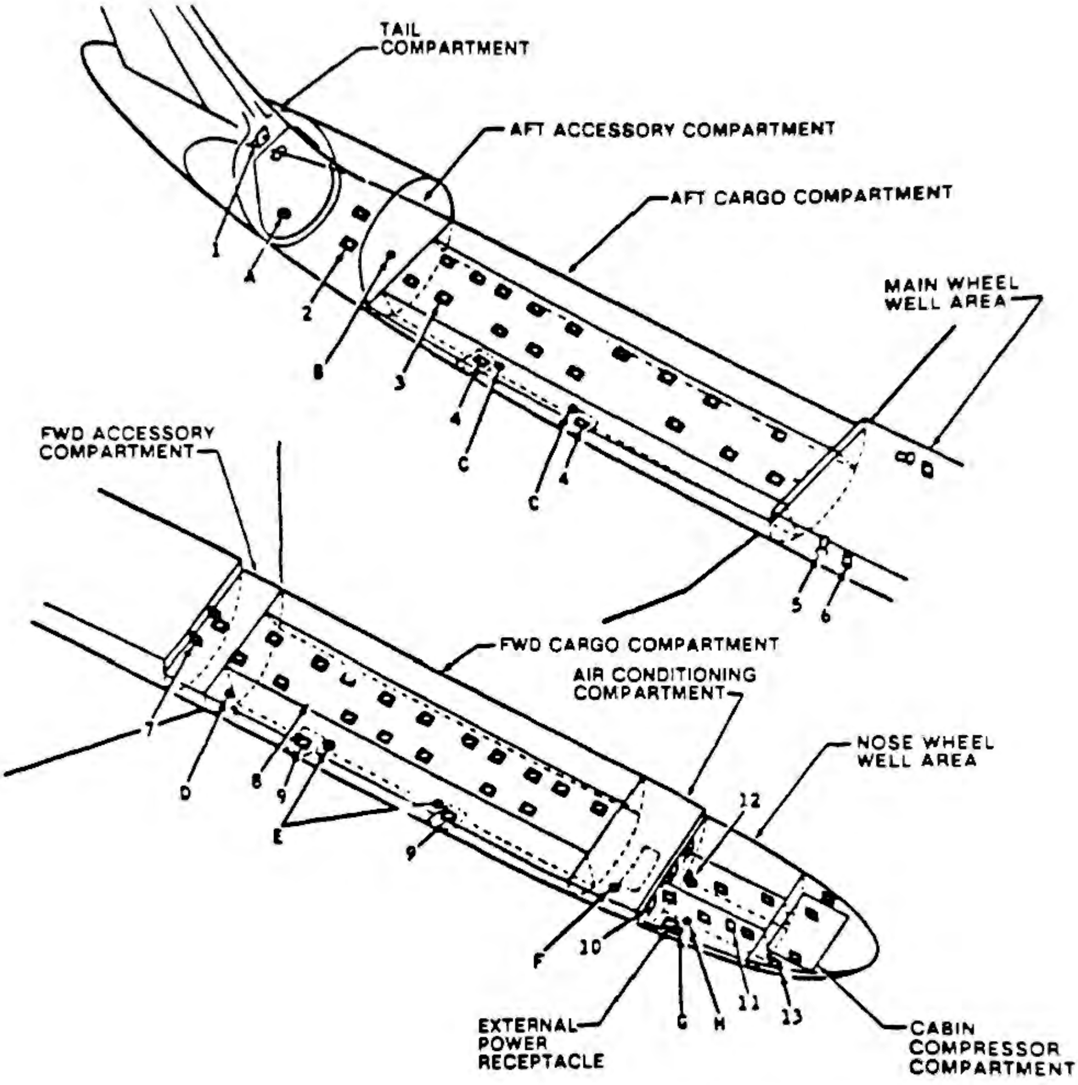
(4) The annunciator system consists of annunciators, two annunciator dim/test boxes, two annunciator power supplies, a dual annunciator light test switch, two annunciator test relays, a warning light dimmer switch and an annunciator test switch.

(5) Captain's and first officer's annunciator dim/test systems operate simultaneously when the WARNING LTS PULL TO DIM switch and/or annunciator LIGHT TEST switch are operated. Circuitry is similar for each system. All annunciators, except for the BELLY DOOR OPEN and CABIN DOOR OPEN annunciators located in center of FE lower left instrument panels, may be dimmed or tested.

9. Cargo and Service Compartments - Description and Operation

A. General (See Figures 33-11, 33-12, 33-13)

The cargo and service compartment lights are installed in the various compartments and accessory areas to facilitate cargo loading, area inspection and servicing. The system consists of cabin compressor and air conditioning compartment lights, forward and aft accessory compartment lights, the nose and main wheel well lights, forward and aft cargo compartment lights, and the tail compartment light. Also included are spotlights located in the nose and main wheel wells used during flight to inspect the position of the down lock links. Control switches for the lights are located adjacent to the compartment or access doors. The nose wheel well inspection light control switch is located in the flight compartment. Step-down transformers reduce 115-vac power to 28-volt power for operation of all service lights. Electrical power for all cargo and service compartment lights is supplied by cabin bus 4.


TAIL COMPARTMENT
AFT ACCESSORY COMPARTMENT
AFT CARGO COMPARTMENT
MAIN WHEEL WELL AREA
1
A
2
B
3
A
C
C
4
C
FWD ACCESSORY COMPARTMENT
5
6
FWD CARGO COMPARTMENT
AIR CONDITIONING COMPARTMENT
NOSE WHEEL WELL AREA
7
D
8
9
E
9
12
F
10
EXTERNAL POWER RECEPTACLE
G
H
11
13
CABIN COMPRESSOR COMPARTMENT

LIGHTS

1. TAIL COMPARTMENT SERVICE
2. AFT ACCESSORY COMPARTMENT SERVICE
3. AFT CARGO COMPARTMENT SERVICE
4. AFT CARGO COMPARTMENT DOOR SPOTLIGHT
5. MAIN WHEEL WELL SPOTLIGHT
6. MAIN WHEEL WELL SERVICE
7. FWD ACCESSORY COMPARTMENT SERVICE
8. FWD CARGO COMPARTMENT SERVICE
9. FWD CARGO COMPARTMENT DOOR SPOTLIGHT
10. AIR CONDITIONING COMPARTMENT
11. NOSE WHEEL WELL SERVICE
12. NOSE WHEEL WELL SPOTLIGHT
13. CABIN COMPRESSOR COMPARTMENT SERVICE

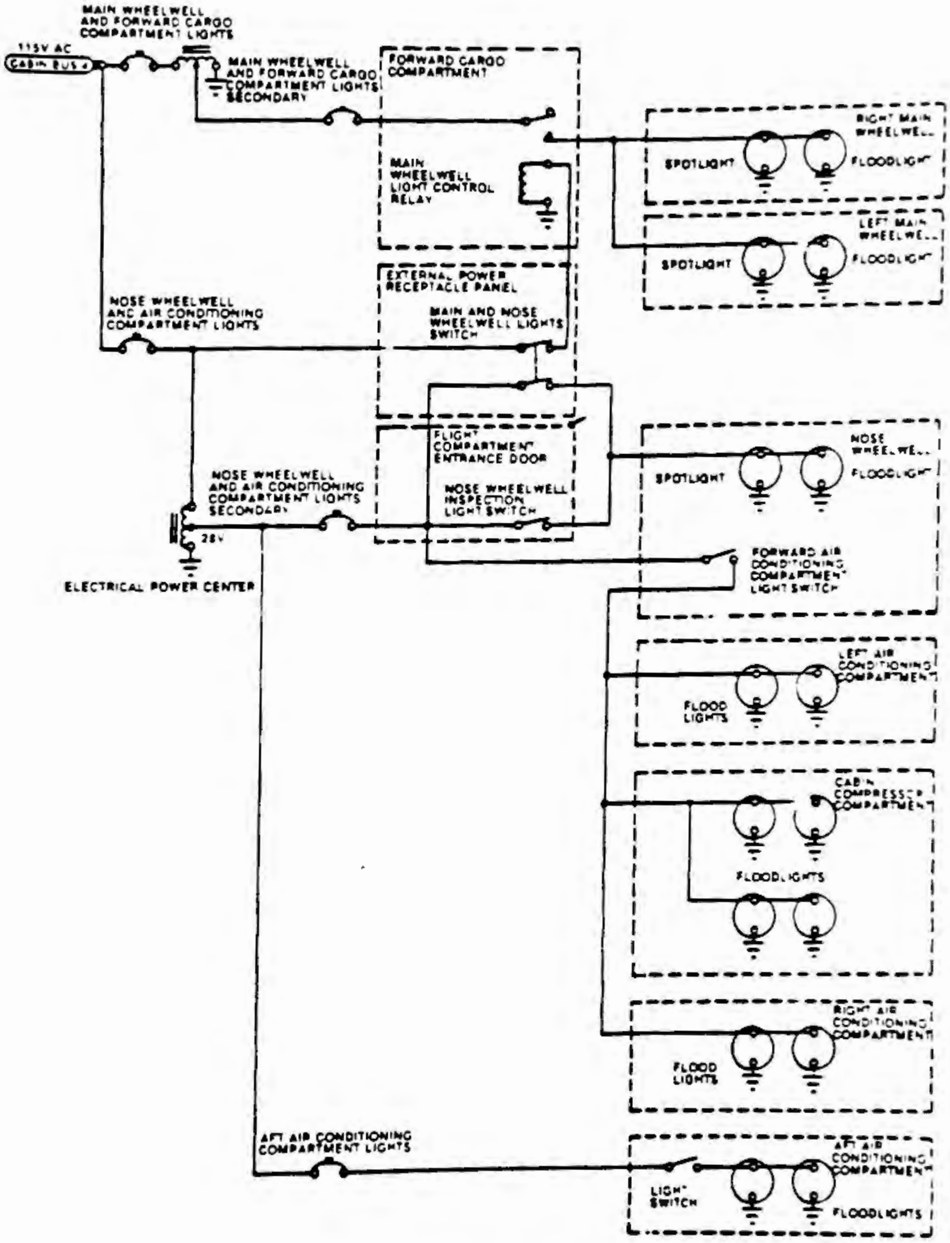
SWITCHES	LIGHTS CONTROLLED
A.	TAIL COMPARTMENT
B.	AFT ACCESSORY COMPARTMENT
C.	AFT CARGO COMPARTMENT
D.	FWD ACCESSORY COMPARTMENT
E.	FWD CARGO COMPARTMENT
F.	AIR CONDITIONING COMPARTMENT
G.	MAIN WHEEL WELL AREA
H.	NOSE WHEEL WELL AREA AND CABIN COMPRESSOR COMPARTMENT

NOTE: NOSE WHEEL WELL AND MAIN WHEEL WELL SWITCHES NOT SHOWN.

CARGO AND SERVICE COMPARTMENT LIGHT LOCATIONS

FTX80208

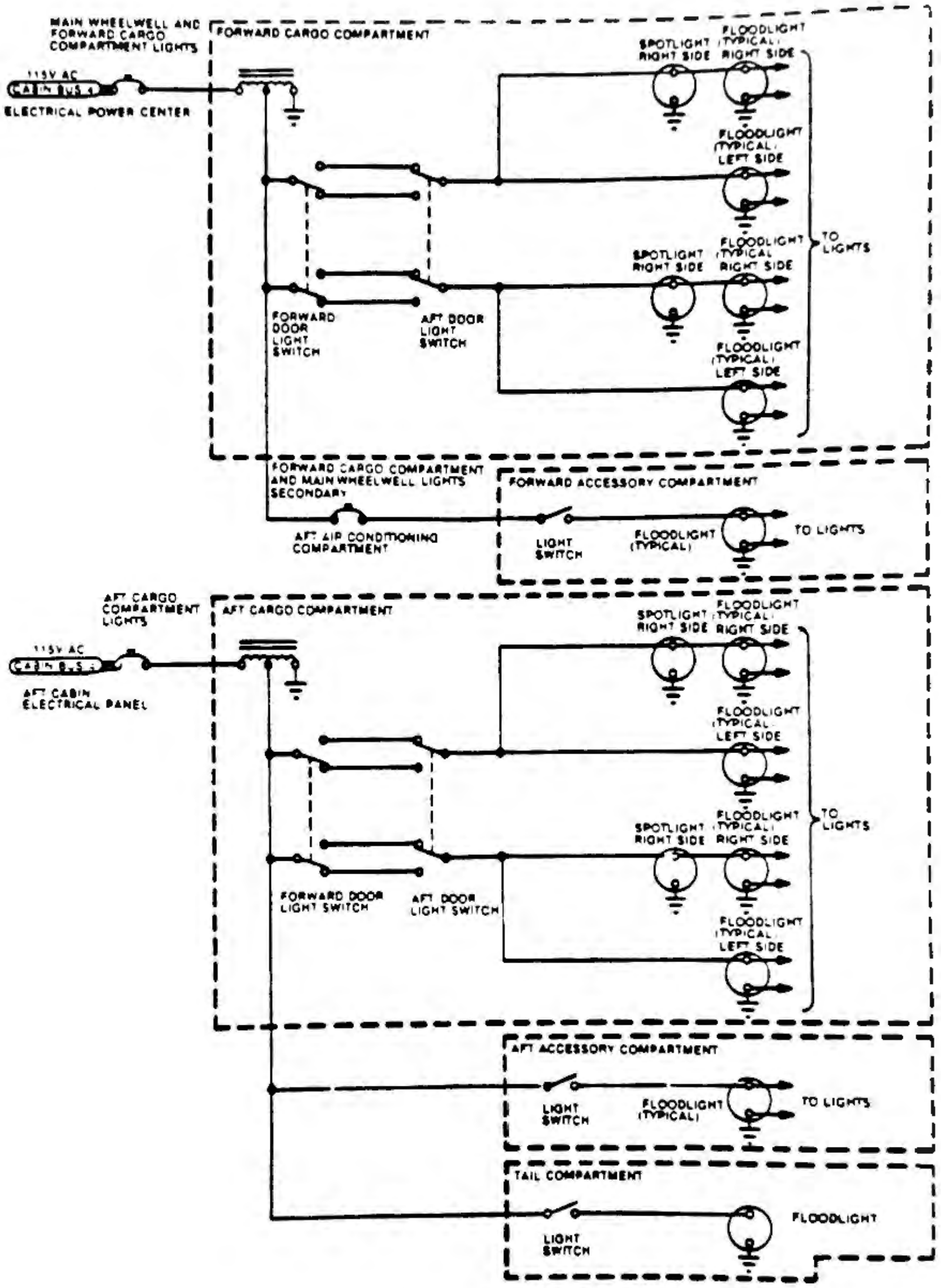
Figure 33-11


MAIN WHEELWELL AND FORWARD CARGO COMPARTMENT LIGHTS
115V AC
CABIN BUS 4
MAIN WHEELWELL AND FORWARD CARGO COMPARTMENT LIGHTS SECONDARY
FORWARD CARGO COMPARTMENT
MAIN WHEELWELL LIGHT CONTROL RELAY
RIGHT MAIN WHEELWELL
SPOTLIGHT
FLOODLIGHT
LEFT MAIN WHEELWELL
SPOTLIGHT
FLOODLIGHT
EXTERNAL POWER RECEPTACLE PANEL
NOSE WHEELWELL AND AIR CONDITIONING COMPARTMENT LIGHTS
MAIN AND NOSE WHEELWELL LIGHTS SWITCH
FLIGHT COMPARTMENT ENTRANCE DOOR
NOSE WHEELWELL
SPOTLIGHT
FLOODLIGHT
NOSE WHEELWELL AND AIR CONDITIONING COMPARTMENT LIGHTS SECONDARY
NOSE WHEELWELL INSPECTION LIGHT SWITCH
28V
ELECTRICAL POWER CENTER
FORWARD AIR CONDITIONING COMPARTMENT LIGHT SWITCH
LEFT AIR CONDITIONING COMPARTMENT
FLOOD LIGHTS
CABIN COMPRESSOR COMPARTMENT
FLOODLIGHTS
RIGHT AIR CONDITIONING COMPARTMENT
FLOOD LIGHTS
AFT AIR CONDITIONING COMPARTMENT LIGHTS
AFT AIR CONDITIONING COMPARTMENT
LIGHT SWITCH
FLOODLIGHTS

NOSE AND MAIN WHEELWELLS AND AIR CONDITIONING COMPARTMENT SERVICE LIGHTS

FTX80209

Figure 33-12


MAIN WHEELWELL AND FORWARD CARGO COMPARTMENT LIGHTS
115V AC
CABIN BUS 4
ELECTRICAL POWER CENTER
FORWARD CARGO COMPARTMENT
SPOTLIGHT RIGHT SIDE
FLOODLIGHT (TYPICAL) RIGHT SIDE
FLOODLIGHT (TYPICAL) LEFT SIDE
SPOTLIGHT RIGHT SIDE
FLOODLIGHT (TYPICAL) RIGHT SIDE
TO LIGHTS
FORWARD DOOR LIGHT SWITCH
AFT DOOR LIGHT SWITCH
FLOODLIGHT (TYPICAL) LEFT SIDE
FORWARD CARGO COMPARTMENT AND MAIN WHEELWELL LIGHTS SECONDARY
FORWARD ACCESSORY COMPARTMENT
AFT AIR CONDITIONING COMPARTMENT
LIGHT SWITCH
FLOODLIGHT (TYPICAL)
TO LIGHTS
AFT CARGO COMPARTMENT LIGHTS
AFT CARGO COMPARTMENT
115V AC
CABIN BUS
AFT CABIN ELECTRICAL PANEL
SPOTLIGHT RIGHT SIDE
FLOODLIGHT (TYPICAL) RIGHT SIDE
FLOODLIGHT (TYPICAL) LEFT SIDE
SPOTLIGHT RIGHT SIDE
FLOODLIGHT (TYPICAL) RIGHT SIDE
TO LIGHTS
FORWARD DOOR LIGHT SWITCH
AFT DOOR LIGHT SWITCH
FLOODLIGHT (TYPICAL) LEFT SIDE
AFT ACCESSORY COMPARTMENT
LIGHT SWITCH
FLOODLIGHT (TYPICAL)
TO LIGHTS
TAIL COMPARTMENT
LIGHT SWITCH
FLOODLIGHT

CARGO, ACCESSORY AND TAIL COMPARTMENT SERVICE LIGHTS

FTX80210

Figure 33-13

10. Main Cargo Compartment Lights - Description and Operation

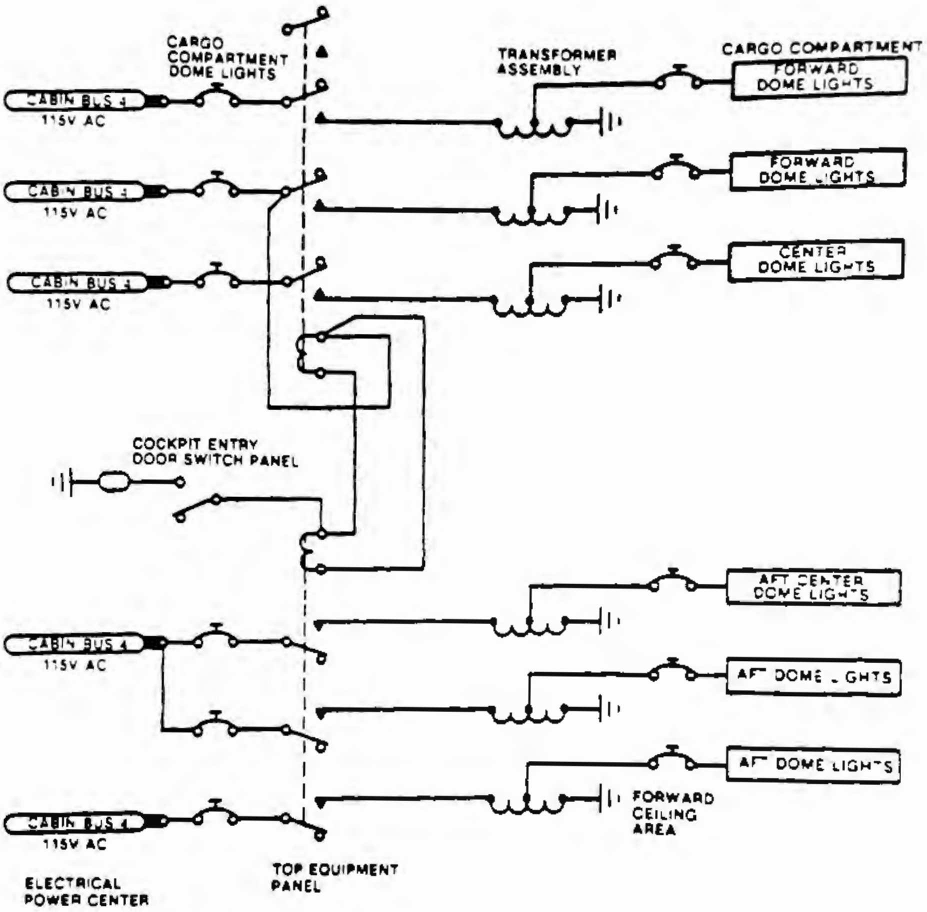
A. General (See Figure 33-14)

The main cargo compartment lights consist of incandescent dome lights installed along the centerline of the main cabin ceiling. The dome lights provide direct lighting of the main cargo floor area for loading, unloading, and inspection. The lights are controlled by a switch on the cockpit entry door switch panel and receive ac power from cabin bus 4.

11. Exterior - Description and Operation

A. General

The exterior lights consist of landing and taxi lights, anticollision lights, navigation lights, and ground and wing floodlights. All exterior light operation manual controls are located in the flight compartment. Separate and combination light selections may be made to obtain optimum lighting for the prevailing environment, operating, and weather conditions.



MAIN CARGO COMPARTMENT DOME LIGHTS

FTX80211

Figure 33-14

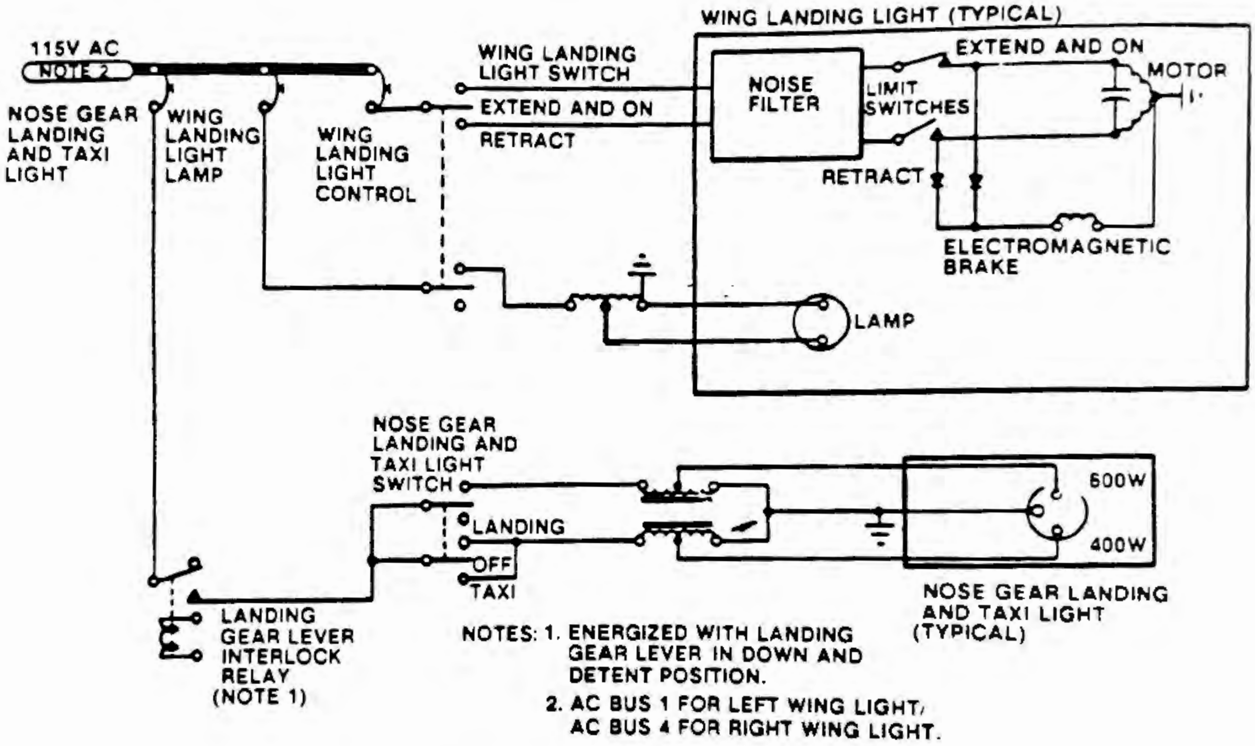
12. Landing and Taxi Lights - Description and Operation

A. General (See Figure 33-15)

(1) The landing and taxi lights consist of the nose gear landing and taxi lights and the wing landing and taxi lights.

(2) The nose gear landing and taxi lights consist of two, fixed position lights installed on the nose landing gear strut. Each light contains a double-filament, sealed-beam lamp in which one filament is rated at 600 watts and the other at 400 watts. The left and right nose gear landing and taxi lights are controlled by separate switches on the flight compartment overhead switch panel. Each switch can be used to select landing (1000 watt) or taxi (400 watt) lighting. The nose gear landing and taxi light circuit is interlocked with the landing gear control relays to prevent the lights from being turned on until the landing gear control handle is in the down and detent position. Electrical power is supplied by ac bus 4.

(3) The wing landing and taxi lights consist of two, retractable light fixtures, installed one in each wing undersurface, inboard of the outer engine pylons and aft of the rear wing spar. Each light contains a 600 watt sealed-beam lamp enclosed in a hinged canopy which may be retracted flush with the wing under surface when not in use, or extended to a forward light beam position during landing and taxi operations. The left and right wing landing and taxi lights are controlled by separate switches on the flight compartment overhead switch panel. In the extend-and-on position, each switch turns on the lamp and applies power to the motor-driven mechanism that extends the lamp and canopy. The mid-position of each switch turns off the lamp but does not retract it. The retract position of each switch applies power to the motor-driven mechanism to retract the lamp and canopy flush with the wing. Extend and retract position limit switches open the motor circuits to prevent overdriving in either position. Electrical power is supplied by ac bus 4.


WING LANDING LIGHT (TYPICAL)
115V AC
NOTE 2
WING LANDING LIGHT SWITCH
EXTEND AND ON
RETRACT
NOISE FILTER
LIMIT SWITCHES
EXTEND AND ON
MOTOR
RETRACT
ELECTROMAGNETIC BRAKE
NOSE GEAR LANDING AND TAXI LIGHT
WING LANDING LIGHT LAMP
WING LANDING LIGHT CONTROL
LAMP
NOSE GEAR LANDING AND TAXI LIGHT SWITCH
LANDING
OFF
TAXI
600W
400W
NOSE GEAR LANDING AND TAXI LIGHT (TYPICAL)
LANDING GEAR LEVER INTERLOCK RELAY (NOTE 1)

NOTES: 1. ENERGIZED WITH LANDING GEAR LEVER IN DOWN AND DETENT POSITION.
2. AC BUS 1 FOR LEFT WING LIGHT/ AC BUS 4 FOR RIGHT WING LIGHT.

LANDING AND TAXI LIGHTS

FTX80212

Figure 33-15

13. Anticollision Light - Description and Operation

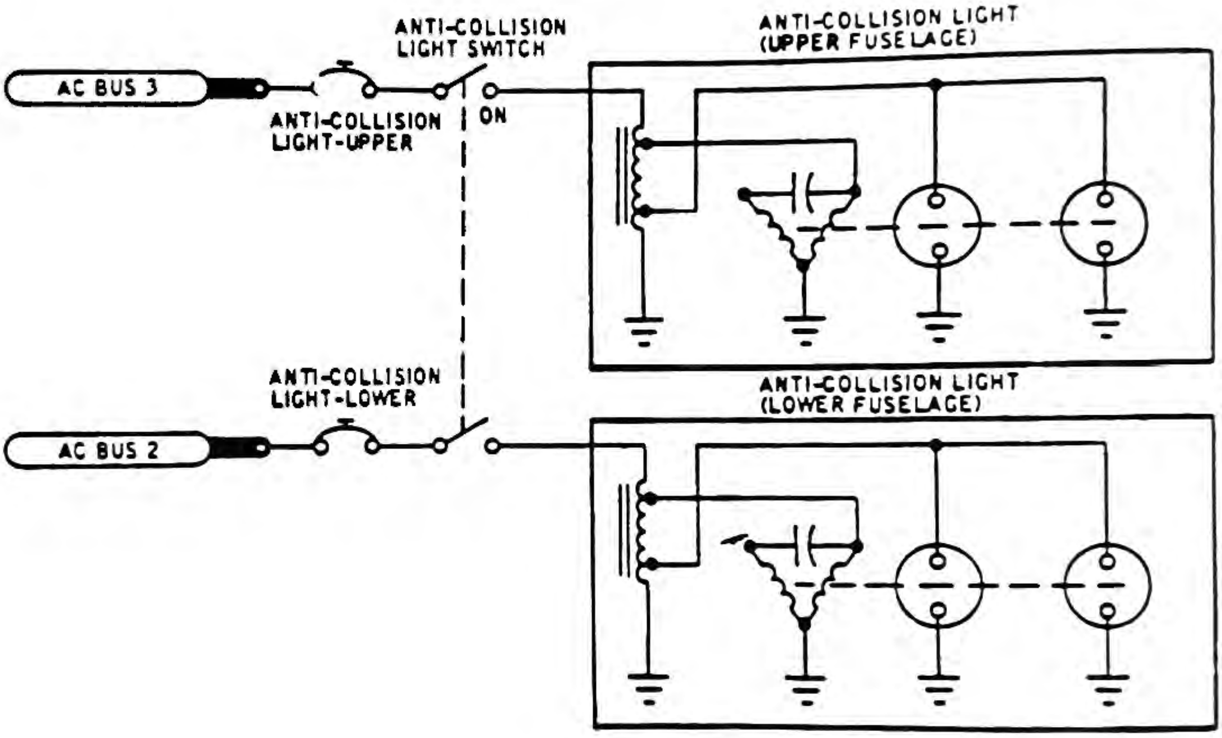
A. General (See Figure 33-16)

The anticollision lights supplement the aircraft visual sighting provisions and consist of light assemblies containing oscillating lights. One anticollision light is installed on the upper fuselage forward of the vertical stabilizer, and the other is installed on the fuselage underside aft of the wing trailing edge. Synchronous hysteresis motors rotate the lamp bases of partially shielded lamps to produce a flashing frequency of 80 flashes per minute. The anti-collision light switch is located on the flight compartment overhead switch panel. Electrical power for the upper light is suppled by ac bus 3, and for the lower light by ac bus 2.

14. Navigation Lights - Description and Operation

A. General (See Figure 33-17)

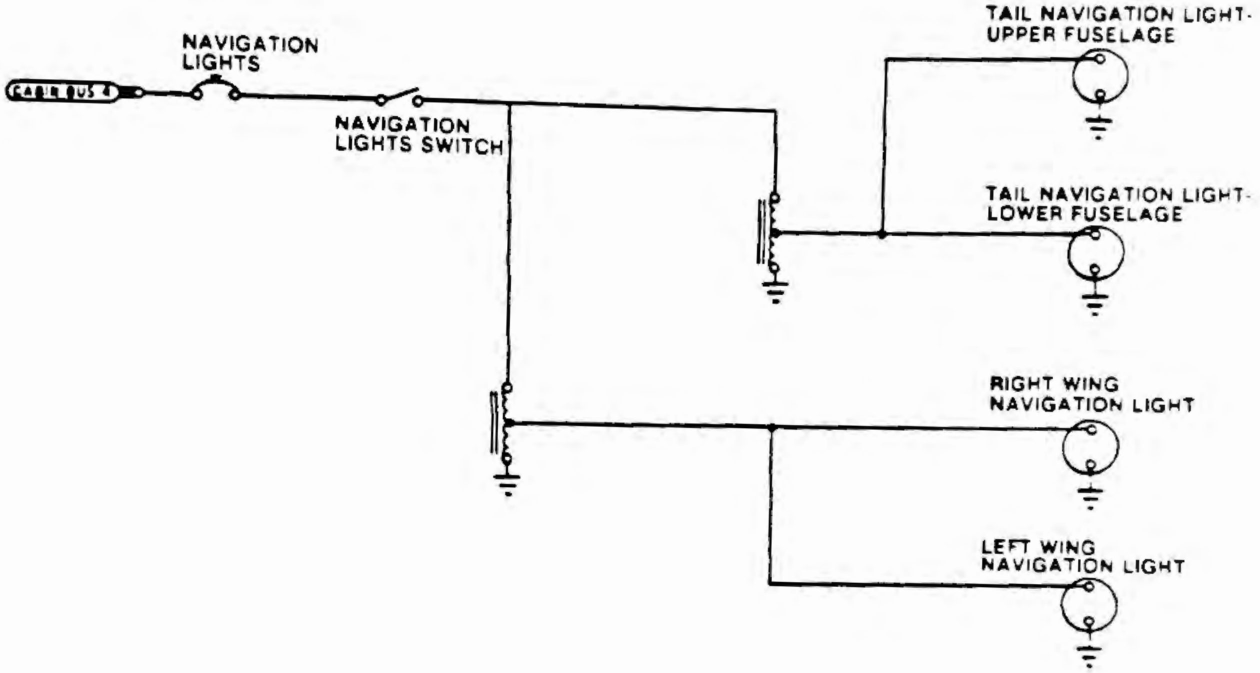
The navigation light system consists of a red light on the left wing tip, a green light on the right wing tip, and two white lights on the tail cone; one on the upper side and one on the underside. The navigation lights are steady, non-flashing type for which the single control switch is located on the flight compartment overhead switch panel. Electrical power for the navigation lights is supplied by cabin bus 4.


ANTI-COLLISION LIGHT SWITCH
ANTI-COLLISION LIGHT (UPPER FUSELAGE)
AC BUS 3
ANTI-COLLISION LIGHT-UPPER
ON
ANTI-COLLISION LIGHT-LOWER
ANTI-COLLISION LIGHT (LOWER FUSELAGE)
AC BUS 2

ANTICOLLISION LIGHTS SCHEMATIC

FTX80213

Figure 33-16


CABIN BUS 4
NAVIGATION LIGHTS
NAVIGATION LIGHTS SWITCH
TAIL NAVIGATION LIGHT-UPPER FUSELAGE
TAIL NAVIGATION LIGHT-LOWER FUSELAGE
RIGHT WING NAVIGATION LIGHT
LEFT WING NAVIGATION LIGHT

NAVIGATION LIGHTS SCHEMATIC

FTX80214

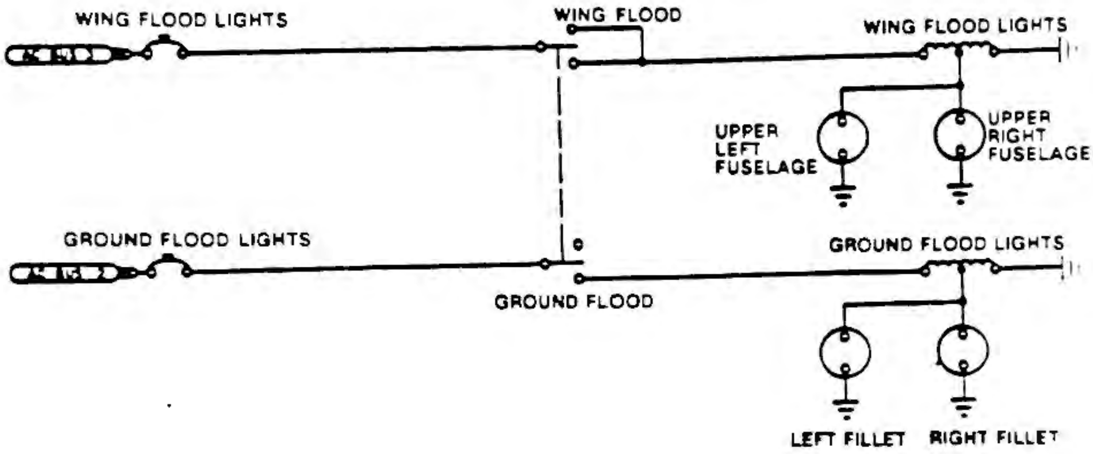
Figure 33-17

15. Wing and Ground Floodlights - Description and Operation

A. General (See Figure 33-18)

(1) The wing and ground floodlights are four, fixed-position assemblies installed one on each side of the fuselage and one in each wing fillet, respectively. the wing floodlights provide sufficient illumination of the wing leading edges and engine nacelles to permit visual inspection of these areas for ice formation in flight. The ground floodlights and the wing floodlights together provide the required illumination for ground refueling and taxiing during night operation.

(2) Each wing and ground floodlight consists of a housing, lamp, and lens. The lights are controlled by a 3-position switch located on the flight compartment overhead switch panel. The positions are wing flood ground flood, and off. The ground flood position turns on both wing and ground floodlights. The wing floodlights receive electrical power from ac bus 3, and the ground floodlights from ac bus 2.



WING AND GROUND FLOODLIGHTS SCHEMATIC

FTX80215

Figure 33-18

16. Emergency Lighting - Description and Operation

A. General

(1) The emergency lighting system consists of an arming switch, a disarmed indicating light, six lighting assemblies, four circuit breakers, and one 24V DC battery pack. If loss of normal electrical power to the aircraft occurs, the emergency lighting system is automatically energized by the battery pack.

(2) The arming switch is used to arm or disarm the emergency lighting system. The disarmed indicating light will be illuminated when the lighting system is disarmed. Both the switches and light are located on the overhead switch panel.

(3) If the emergency lighting system is armed, and a power loss on the 28V DC Bus No. 1 occurs, three lights beneath the pilot's glare shield, the flight deck dome light, the crew coat closet light and the forward entrance door light will illuminate.

(4) One 24 volt DC rechargeable batter vides power for the emergency lights and is located abo vard entrance door.

(5) Four circuit breakers are used in th ıcy lighting system to provide power for arming, disarmir charging and control.

B. Operations

(1) The emergency lights arming swi ree positions: arm, disarm and disarm check. It is located on ıead switch panel, and provides means to arm, disarm, or check if the system is completely disarmed. With the switch in the armed position, the lights can be turned on by pulling the emergency exit light control circuit breaker located on the 28V DC Bus No. 1. The lights will be powered from the emergency exit lights circuit breaker located on the 28V left emergency DC bus. By pulling this circuit breaker the lights would then be powered by the emergency battery charging circuit breaker located on the emergency AC bus through the emergency battery charging circuit. With the emergency battery charging circuit breaker pulled, the lights would then be powered by the emergency battery pack. The

fourth circuit breaker is the emergency lights arming and indicating, located on the 28V DC battery bus which provides power for arming, disarming and the disarmed indicating light.

(2) An amber press-to-test dimable emergency lights disarmed indicating light is located on the overhead switch panel. With electrical power applied to the aircraft and the arm switch in the armed position, the emergency lights disarmed indicating light will be extinguished. Placing the switch to the disarm position will cause the indicating light to illuminate and the emergency lights will not come on when electrical power is removed from the aircraft.

(3) The emergency lights arming switch is placed in the armed position when completing the before start checklist and placed in the disarm check and disarmed positions when accomplishing the shutdown checklist.

CAUTION: **THE EMERGENCY LIGHTS ARMING SWITCH SHOULD BE PLACED TO THE DISARMED POSITION WITH THE BATTERY BUS POWERED AND BEFORE TURNING OFF ALL ELECTRICAL POWER.**

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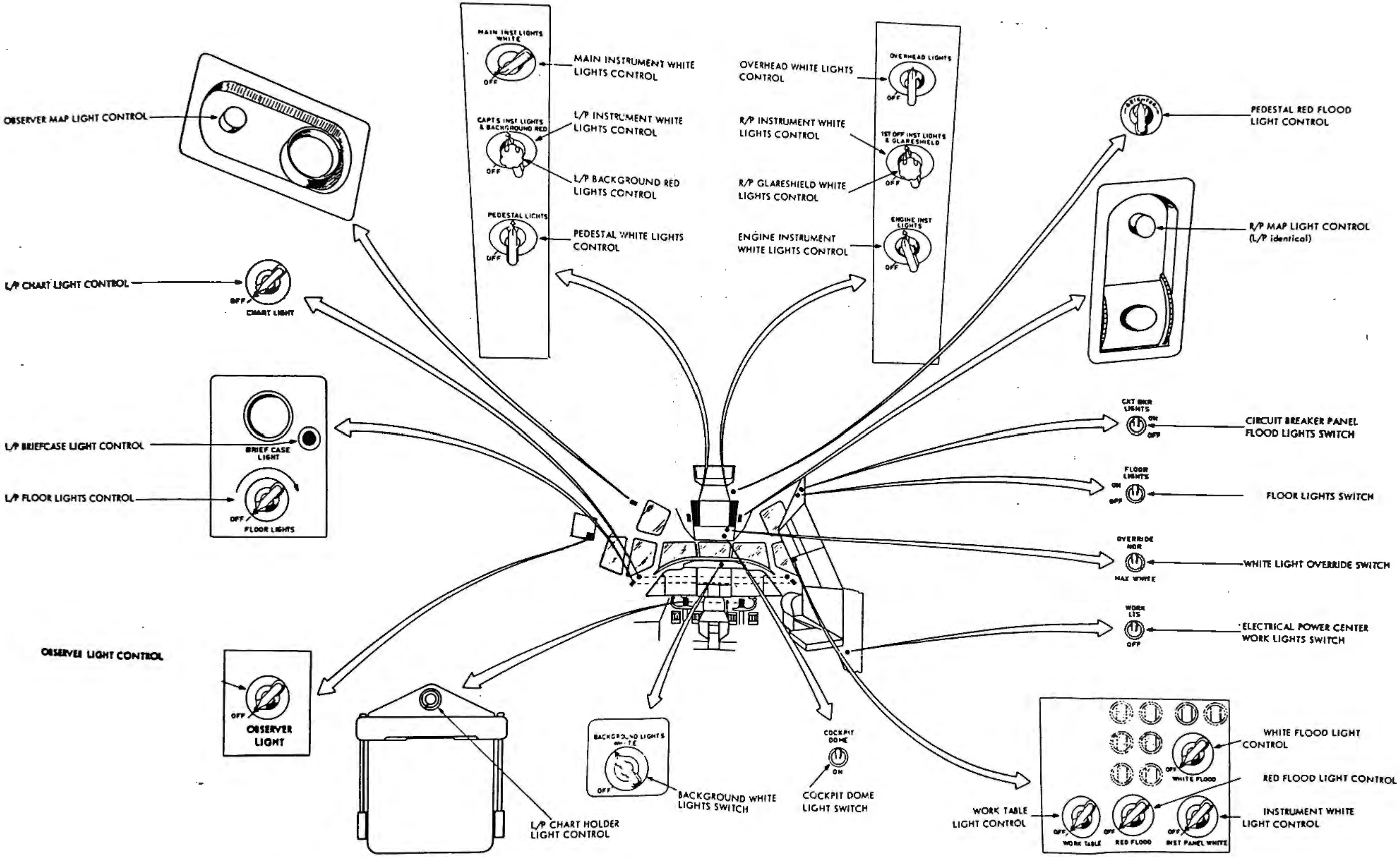

OBSERVER MAP LIGHT CONTROL
MAIN INST LIGHTS WHITE
OFF
MAIN INSTRUMENT WHITE LIGHTS CONTROL
CAPT'S INST LIGHTS & BACKGROUND RED
OFF
L/P INSTRUMENT WHITE LIGHTS CONTROL
L/P BACKGROUND RED LIGHTS CONTROL
PEDESTAL LIGHTS
OFF
PEDESTAL WHITE LIGHTS CONTROL
OVERHEAD LIGHTS
OFF
OVERHEAD WHITE LIGHTS CONTROL
1ST OFF INST LIGHTS & GLARESHIELD
OFF
R/P INSTRUMENT WHITE LIGHTS CONTROL
R/P GLARESHIELD WHITE LIGHTS CONTROL
ENGINE INST LIGHTS
OFF
ENGINE INSTRUMENT WHITE LIGHTS CONTROL
BRIGHTER
PEDESTAL RED FLOOD LIGHT CONTROL
R/P MAP LIGHT CONTROL (L/P identical)
L/P CHART LIGHT CONTROL
OFF
CHART LIGHT
BRIEF CASE LIGHT
L/P BRIEFCASE LIGHT CONTROL
L/P FLOOR LIGHTS CONTROL
OFF
FLOOR LIGHTS
CKT BKR LIGHTS
ON
OFF
CIRCUIT BREAKER PANEL FLOOD LIGHTS SWITCH
FLOOR LIGHTS
ON
OFF
FLOOR LIGHTS SWITCH
OVERRIDE NOR
MAX WHITE
WHITE LIGHT OVERRIDE SWITCH
WORK LTS
OFF
ELECTRICAL POWER CENTER WORK LIGHTS SWITCH
OBSERVER LIGHT CONTROL
OFF
OBSERVER LIGHT
L/P CHART HOLDER LIGHT CONTROL
BACKGROUND LIGHTS WHITE
OFF
BACKGROUND WHITE LIGHTS SWITCH
COCKPIT DOME
ON
COCKPIT DOME LIGHT SWITCH
WHITE FLOOD LIGHT CONTROL
OFF
WHITE FLOOD
RED FLOOD LIGHT CONTROL
WORK TABLE LIGHT CONTROL
OFF
WORK TABLE
OFF
RED FLOOD
OFF
INST PANEL WHITE
INSTRUMENT WHITE LIGHT CONTROL

Flight compartment lighting controls

1. Description (See Figure 36-1)

A. The low-pressure pneumatic system distributes and controls bleed air from either of two compressor sections of the engine or from a ground source through the connector forward of the nosewheel well. the pneumatic manifold extends from the outboard pylons, spanwise through the wing. and forward in the fuselage to the nose section. In the nose section. the left and right sections of the manifold are joined by a crossfeed valve. The right section is also connected to the ground source connector through the right rain removal duct.

B. Air is bled from the pneumatic manifold to operate the air conditioning and refrigeration components and to provide for ice protection and windshield rain removal for cowl and engine anti-icing. Air for engine starting can also be provided by the pneumatic system.

The following pneumatic system controls, indicators, warning lights, and indicating lights are provided for controlling and monitoring the pneumatic system:

(1) Control switches

(2) Manifold air temperature indicator

(3) Manifold air overtemperature warning light

(4) Manifold failure indicating lights

(5) Manifold air pressure indicator

(6) Manifold air pressure indicating light

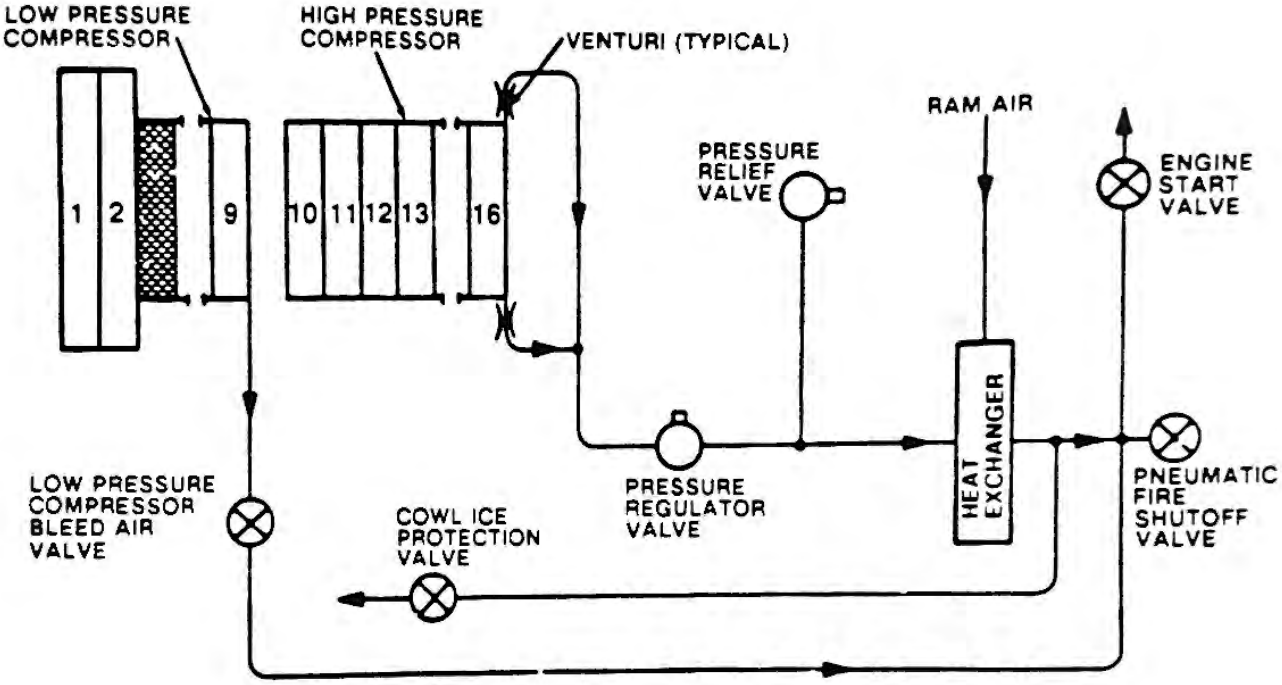
C. Blowout doors are used to prevent structural damage due to a pressure buildup in the event of a high-flow leak in the pneumatic ducts. Blowout doors are located in the following areas:

(1) Lower surface of the wing leading edge between the inboard and outboard pylons

(2) In each of the four pylons

(3) In the nose cowl of each engine

(4) In the engine access doors



PNEUMATIC SYSTEM MECHANICAL SCHEMATIC

FTX80456

Figure 36-1

2. To Operate System

A. Pressurizing Pneumatic System Utilizing Engines

(1) Check that following controls are in positions indicated.

Control	Position
Thrust brake levers	Forward
Fire control handles	Normal
Windshield rain removal levers	Off
Engine anti-icing switches	Off
Scoops anti-icing switch	Off
Airfoil deicing switch	Off
Cabin compressor switches	Off
Refrigerant compressor switches	Off
Pneumatic manifold crossfeed switch	Normal
Pneumatic system shutoff switches	Off

(2) Start engine or engines

(a) One engine (No. 2 or No. 3) for pressurizing manifold and pressure tests requiring limited capacity.

(b) Two engines (No. 2 and No. 3) for stabilizing temperature on each side and for greater capacity for using systems.

(c) All four engines for all systems' checkouts.

(3) Place low-pressure pneumatic shutoff switches, located on systems engineer's panel, in high position.

(4) Slowly advance throttles from idle position and check following:

(a) Manifold air pressure light goes off as pressure increases above 15.5 psig, as shown on manifold pressure indicator.

(b) Manifold air pressure increases to and stabilizes at 38 (±2) psig.

NOTE: This light also comes on when an overpressure condition exists and a relief valve opens. When the airplane is on the ground with a throttle advanced less than approximately 18 degrees (1 9/16 inch) from the idle stop, the corresponding regulator valve is open and air is supplied from the high-pressure compressor bleed ports. When the throttle is advanced past approximately 18 degrees from the idle stop, the throttle limit switch is actuated which closes the regulator valve and opens the low-pressure compressor bleed valve to supply air from the low-pressure compressor bleed ports. The control circuit changes the bleed source back to the high-pressure source when the airplane leaves the ground.

(5) Retard throttle and repeat steps (4 and 5) for engines 2, 3 and 4.

B. Pressurizing pneumatic system utilizing ground pneumatic source

(1) Check that following controls are in positions indicated:

Control	Position
Starter and ignition arming switch	Off
Fire control handles	Normal
Windshield rain removal levers	Off
Engine anti-icing switches	Off
Scoops anti-icing switch	Off
Airfoil deicing switch	Off

Cabin compressor switches	Off
Refrigerant compressor switches	Off
Pneumatic manifold crossfeed switch	Normal
Pneumatic system shutoff switches	Off

3. Distribution

A. General

(1) The air for the low-pressure pneumatic distribution system is supplied by the low-pressure or high-pressure compressors of each engine and is distributed through a system of ducts and valves. The high-pressure compressor bleed air is supplied at a regulated pressure and temperature. When the low-pressure compressor source is selected, air is supplied at compressor pressure and temperature.

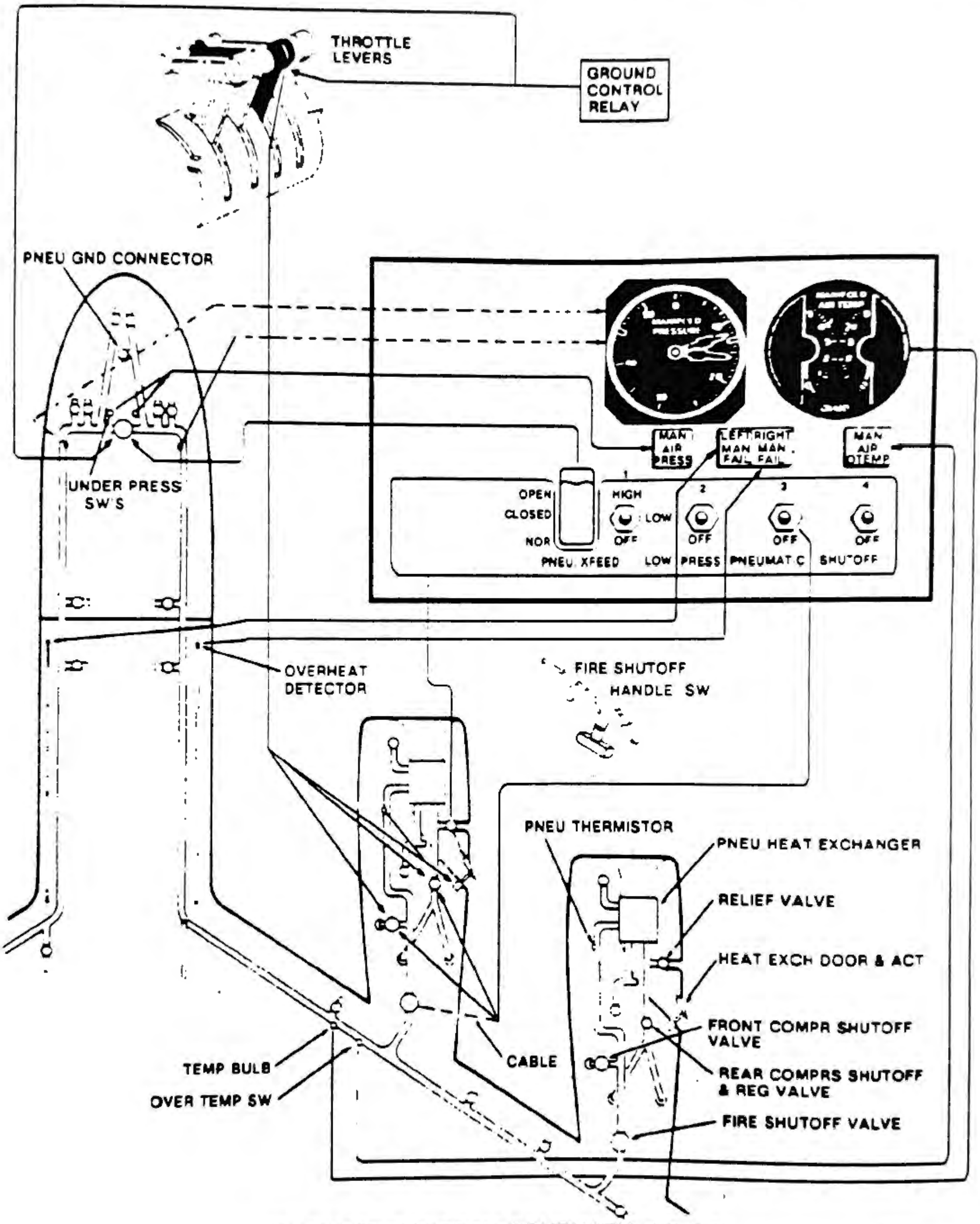
(2) An external source of air can be connected to supply the pneumatic system when the airplane is on the ground and the engines are not operating.

B. Description (See Figure 36-2)

(1) High-pressure bleed air is ducted from two bleed ports in the engine diffuser case through a pressure regulator valve, past a pressure relief valve, and into the heat exchanger. From the heat exchanger, the air is ducted through the pylon duct, the pneumatic fire shutoff valve, and into the pneumatic manifold.

(2) Low-pressure bleed air is ducted from a bleed port in the compressor case through a shutoff valve and a duct that is teed into the pylon duct.

(3) The pneumatic manifold starts at the outboard pylon in each wing and extends to the fuselage and into the fuselage nose section where the left and right sections are connected by a crossfeed valve. Pressurized air for the using systems is bled from the manifold.



PNEUMATIC SYSTEM SCHEMATIC DC-8-61

FTX80639

Figure 36-2

C. Operation

The pneumatic shutoff switches are provided to select either compressor source of the corresponding engine. During ground operations when the switch is in the high position, the source is automatically transferred to the low-pressure bleed when the engine throttle is advanced past approximately 18 degrees from the idle stop. The high position is used for takeoff and descent and during periods requiring ice protection. The low position can be used during climb and cruise when ice protection is not required.

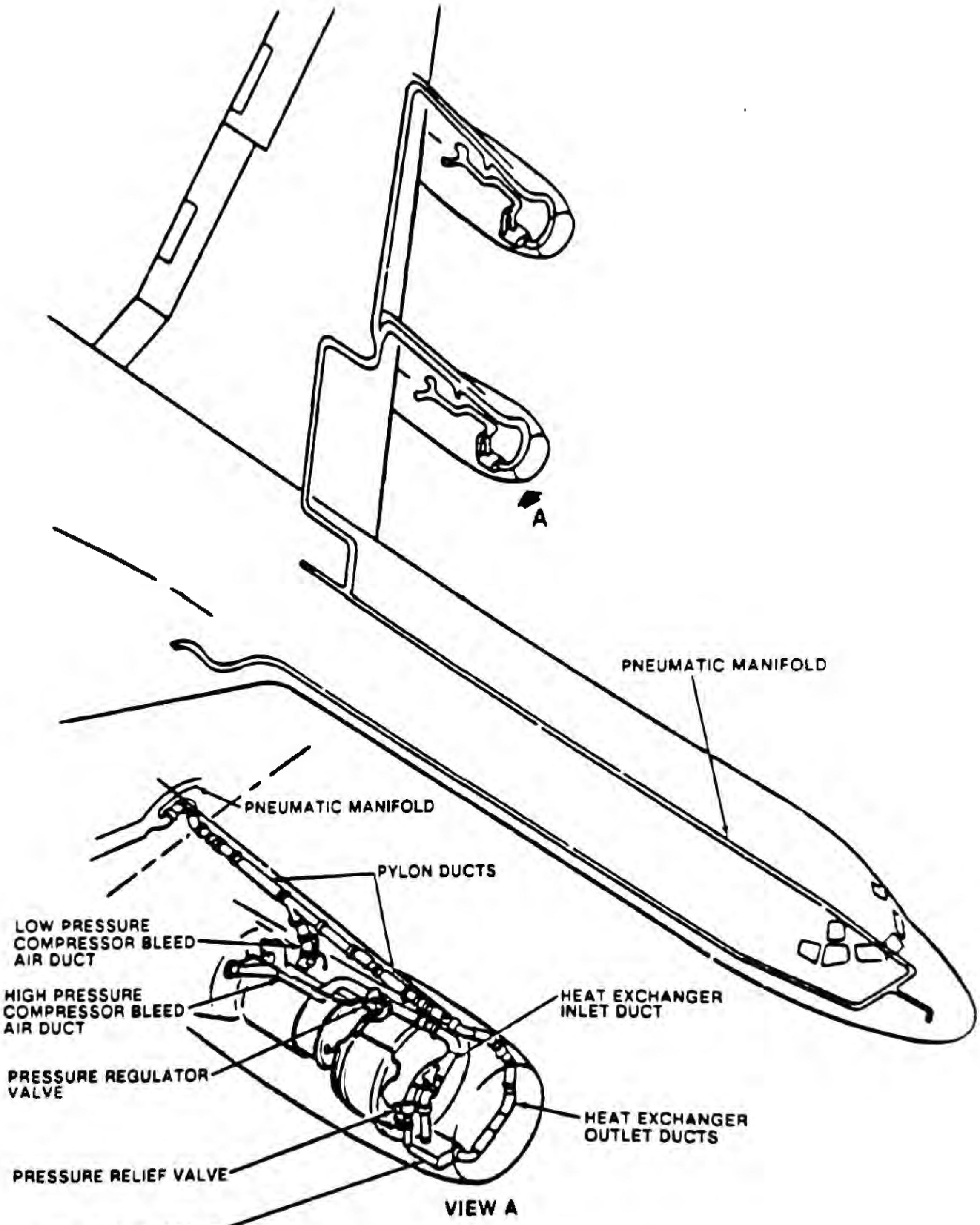
4. Ducting

A. General (See Figure 36-3)

(1) Engine bleed air is distributed throughout the airplane by a system of ducts. All ducts downstream of the heat exchanger are insulated. The insulation generally consists of layers of baked fiberglass covered with neoprene. The ends of the covering, which are in contact with the duct, are made of a silicone-impregnated fiberglass cloth that can withstand the high duct temperatures.

(2) The system of ducts in the heat exchanger inlet and outlet ducts system is referred to as a tension system because the ducts are subjected to tension loads when the pneumatic system is in operation. The ducts, between the heat exchanger and the pressure regulator valve, are connected by a metal bellows and knuckle-joint (universal joint) combination and supported by linkages. This method of installation permits movement of the ducts to compensate for expansion and contraction of the ducts and engine.

(3) The system of ducts forming the pneumatic manifold is referred to as compression system because the ducts are subjected to compression loads when the pneumatics system is in operation. One end of each manifold assembly is held rigid by a fixed support. A slip-type support at the other end allows the duct assemblies to expand and contract with changes in temperature. the slip supports also allow the ducts to slip freely during airplane structural deflections. The duct assemblies are joined by flexible connectors made from a silicone-impregnated fiberglas material.


A
PNEUMATIC MANIFOLD
PNEUMATIC MANIFOLD
PYLON DUCTS
LOW PRESSURE COMPRESSOR BLEED AIR DUCT
HIGH PRESSURE COMPRESSOR BLEED AIR DUCT
PRESSURE REGULATOR VALVE
PRESSURE RELIEF VALVE
HEAT EXCHANGER
HEAT EXCHANGER INLET DUCT
HEAT EXCHANGER OUTLET DUCTS
VIEW A

PNEUMATIC SYSTEM DUCTING

FTX80457

Figure 36-3

B. Component Description

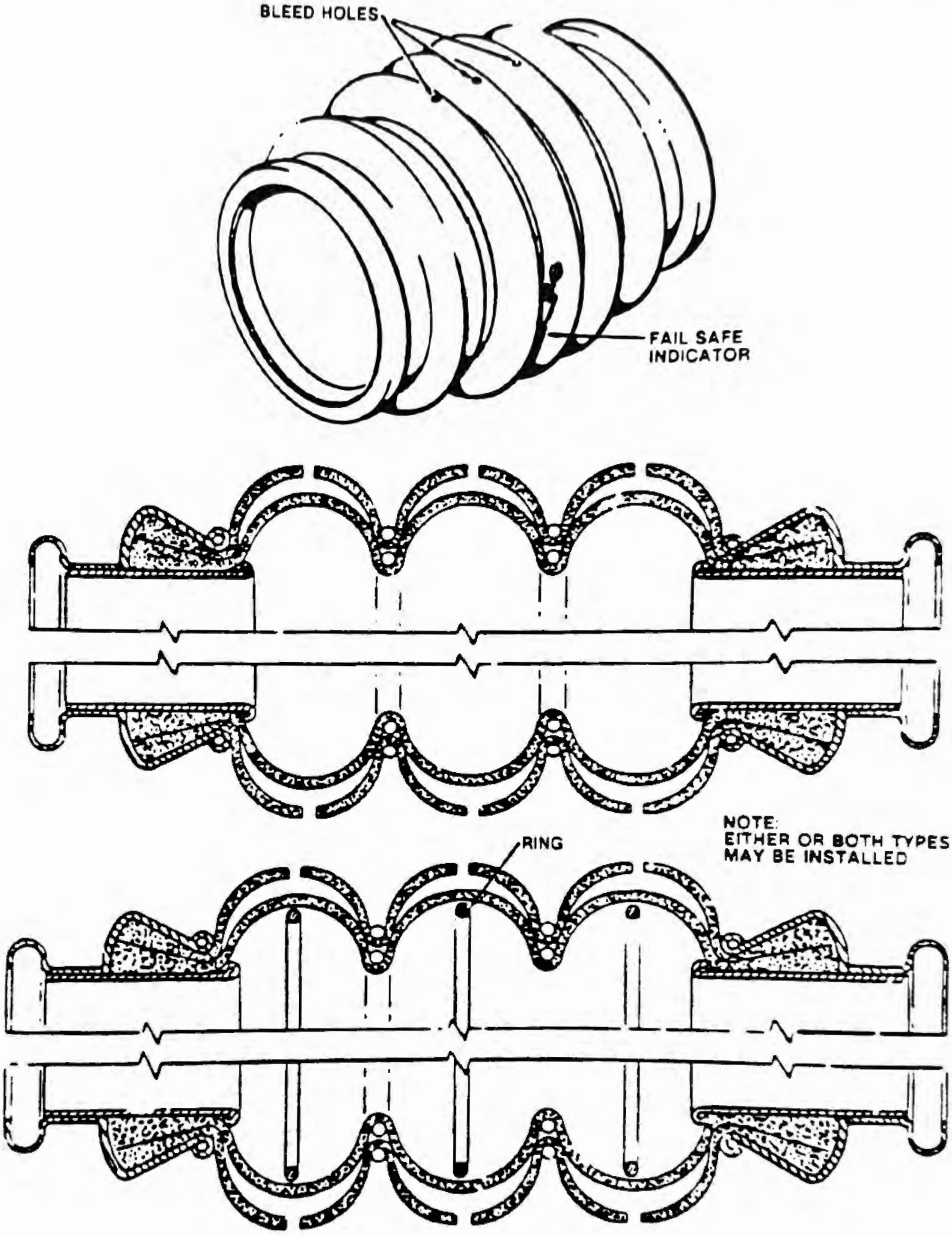
(1) Duct Connectors (See Figure 36-4)

(a) The duct connectors are double wall type connectors. The connectors permit expansion and contraction of the pneumatic ducts with changes in temperature and allow for structural deflection.

(b) The connectors are installed in the pylons, wings, on both sides of the fuselage, and in the fuselage nose section. The connectors are attached to the manifold duct assemblies with v-band type couplings. The bellows-shaped walls of the connectors are made from a silicone-impregnated fiberglas material and have a coupling flange attached to each end. A spring-loaded, fail-safe indicator is attached to a metal band circling the connector (See Figure 36-5). If the inner wall of the connector should leak excessively, expansion of the outer wall causes the metal strip to expand and thereby allow a spring-loaded flag (indicator) to snap out of the strap bracket. Normal inner wall leakage is less than 0.003 pounds of air per minute per inch diameter. The outer wall is vented to compensate for this normal inner wall leakage.

(2) High-Pressure Bleed Port Duct (See Figure 36-6)

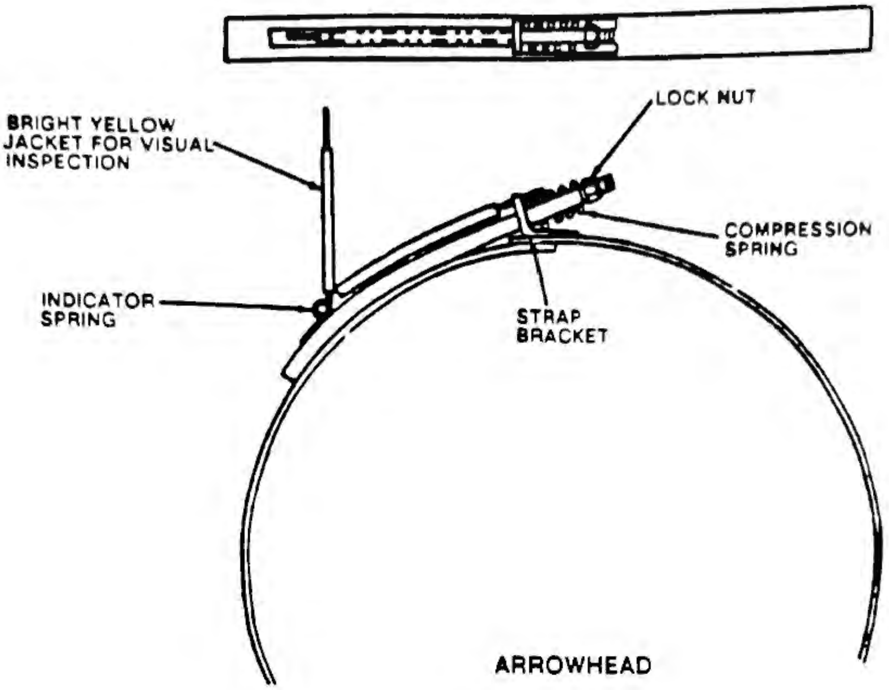
A high-pressure bleed port duct is installed on the upper surface of each engine. Access to the duct is gained by removing the engine. The duct is a y-duct with a flow-limiting venturi in each branch of the wye High-pressure compressor bleed air is directed by the duct from two bleed ports in the engine diffuser case to the pressure regulator valve. In case of a regulator, relief valve or manifold failure the venturis limit the flow of air from the engine to a maximum of 14 pounds per second, 7 pounds per second through each venturi.



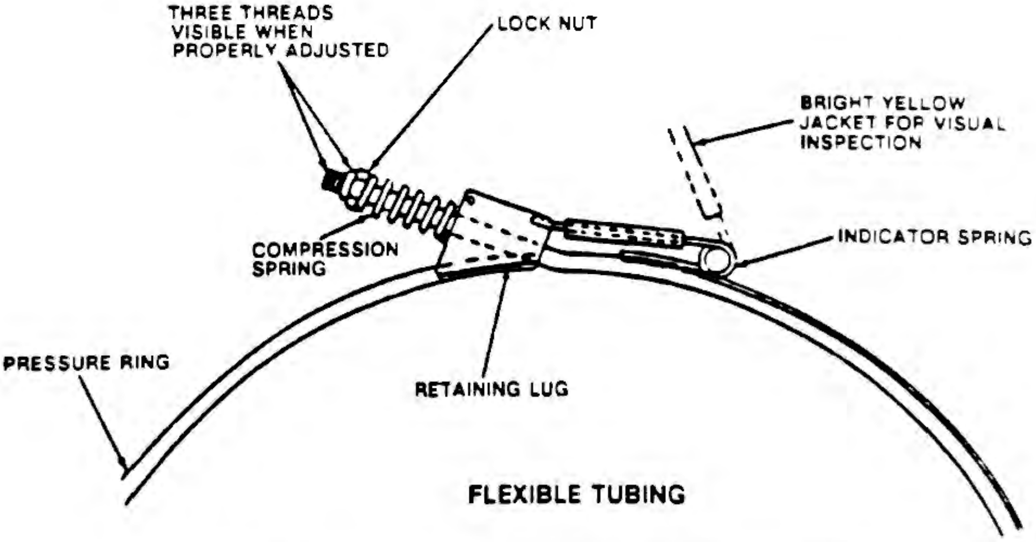
NOTE:
EITHER OR BOTH TYPES MAY BE INSTALLED

DOUBLE-WALL CONNECTOR

Figure 36-4



ARROWHEAD

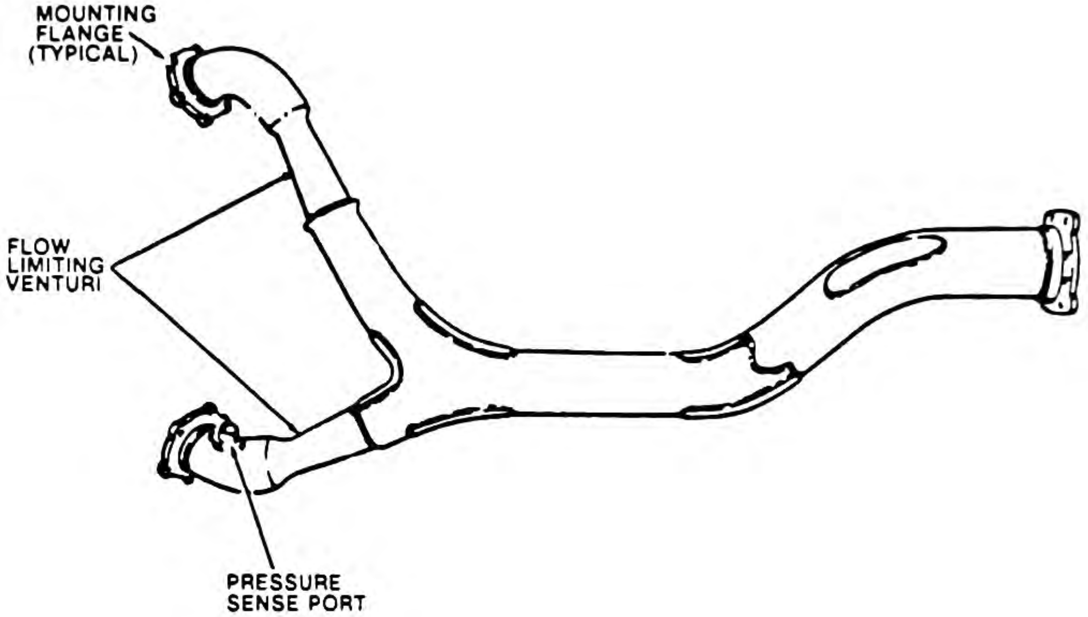

THREE THREADS VISIBLE WHEN PROPERLY ADJUSTED
LOCK NUT
BRIGHT YELLOW JACKET FOR VISUAL INSPECTION
INDICATOR SPRING
COMPRESSION SPRING
PRESSURE RING
RETAINING LUG

FLEXIBLE TUBING

FAIL-SAFE INDICATOR ADJUSTMENT DIAGRAM

FTX80459

Figure 36-5



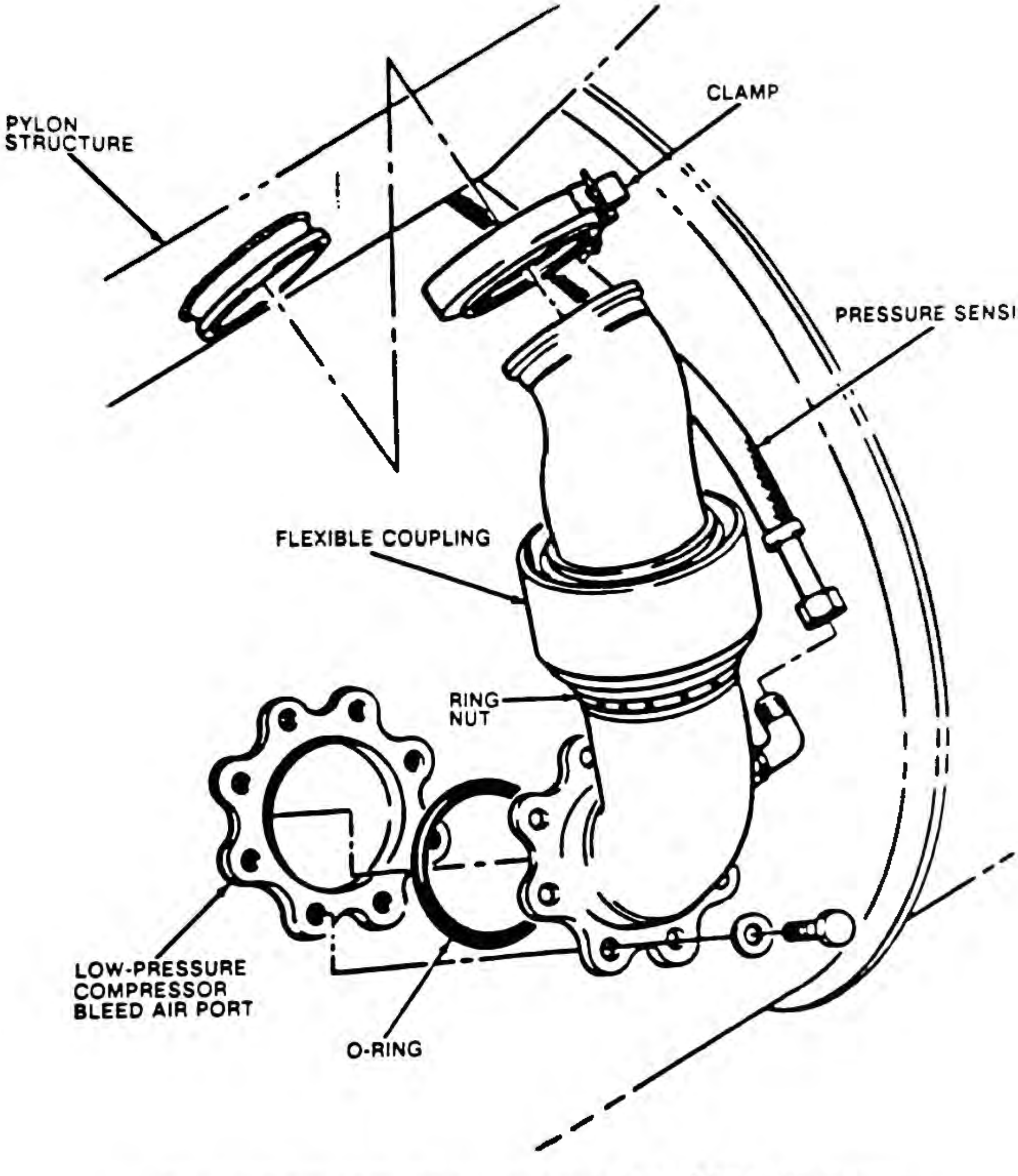
HIGH-PRESSURE BLEED PORT DUCT

FTX80460

Figure 36-6

(3) Low-pressure Bleed Port Duct (See Figure 36-7)

A low-pressure bleed port duct is installed approximately at the 10 o'clock position on the compressor intermediate case of each engine. The duct supplies low-pressure compressor bleed air from a bleed port in the compressor intermediate case through an adapter to the low-pressure valve. The duct is attached to the bleed port with cap screws and is sealed to the bleed port with a stainless-steel O-ring. the outlet of the duct is connected to a flexible coupling assembly by a ring nut and sealed with an O-ring. A pressure sensing port is located on the aft side of the duct for the low-pressure compressor bleed air valve.



LOW-PRESSURE COMPRESSOR BLEED AIR DUCT

FTX80461

Figure 36-7

(4) Heat Exchanger Inlet Ducts (See Figure 36-8)

The heat exchanger inlet ducts, installed between the pressure regulator valve and the heat exchanger, are located on the forward side of the engine. One of the duct sections is y-shaped with a pressure relief valve in one branch of the wye and the other branch connected to the heat exchanger.

(5) Heat Exchanger Outlet Ducts (See Figure 36-9)

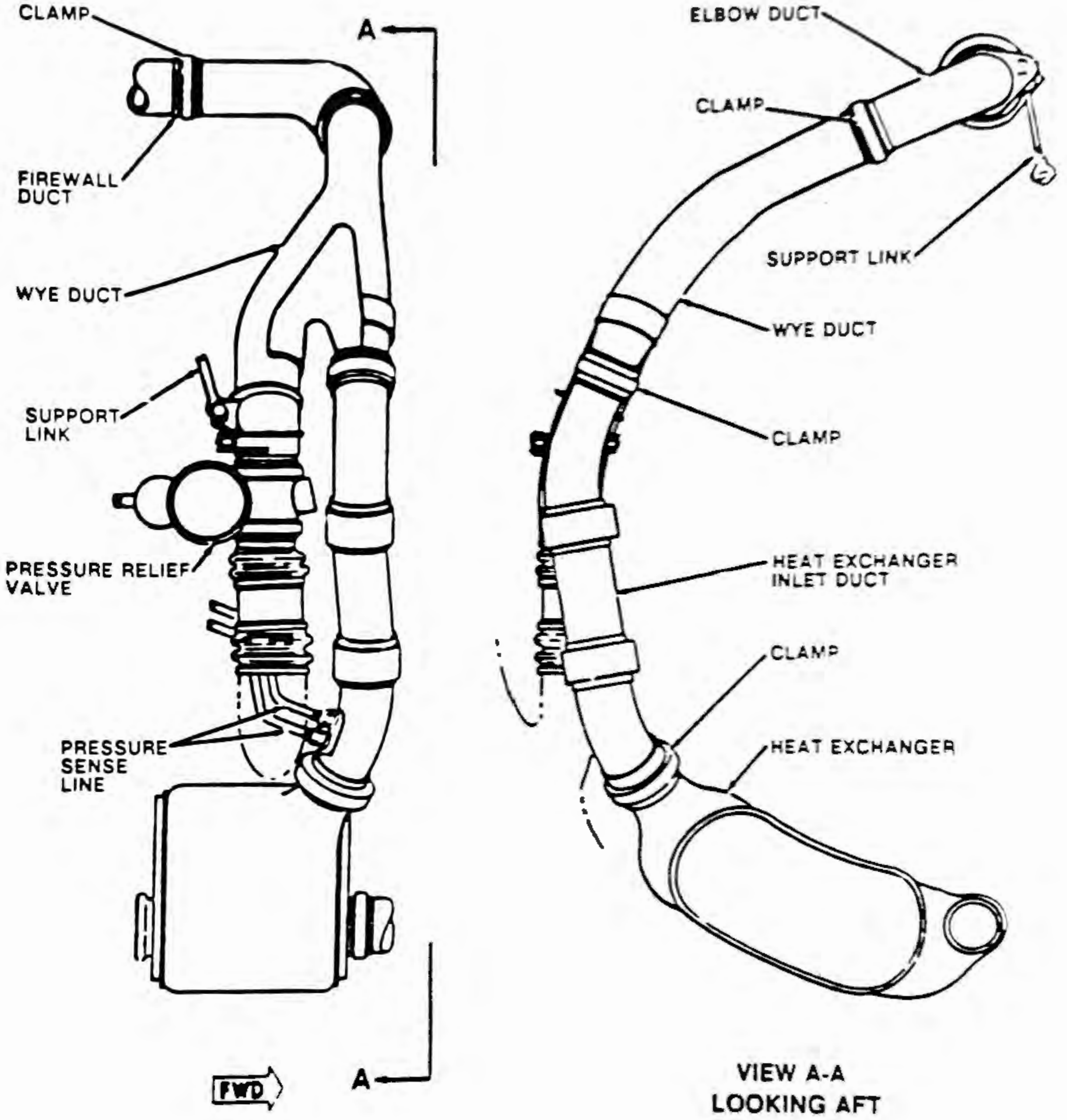
The heat exchanger outlet ducts start at the heat exchanger in the bottom of the nose section of the nacelle, extend around the left side, and end at the top of the engine where they connect to the pylon ducts.

(6) Pylon Ducts (See Figures 36-10 and 36-11)

The pylon ducts are located in the pylon nose section, and are installed between the heat exchanger outlet ducts and the pneumatic manifold. The engine pneumatic fire shutoff valve is located in the pylon duct system near the manifold.

(7) Pneumatic Manifold

The pneumatic manifold extends inboard from the pylons to the fuselage nose section. The portion of the pneumatic manifold from the outboard pylon to the fuselage, except in the inboard pylon area, is an integral part of the leading edge and is removed with the wing leading edge. The manifold extends forward along each side of the fuselage, below the floor, in the pressurized area. From the pressurized area the left and right sections of the manifold extend forward and are joined in the fuselage nose section by the pneumatic crossfeed valve.



HEAT EXCHANGER INLET DUCTS

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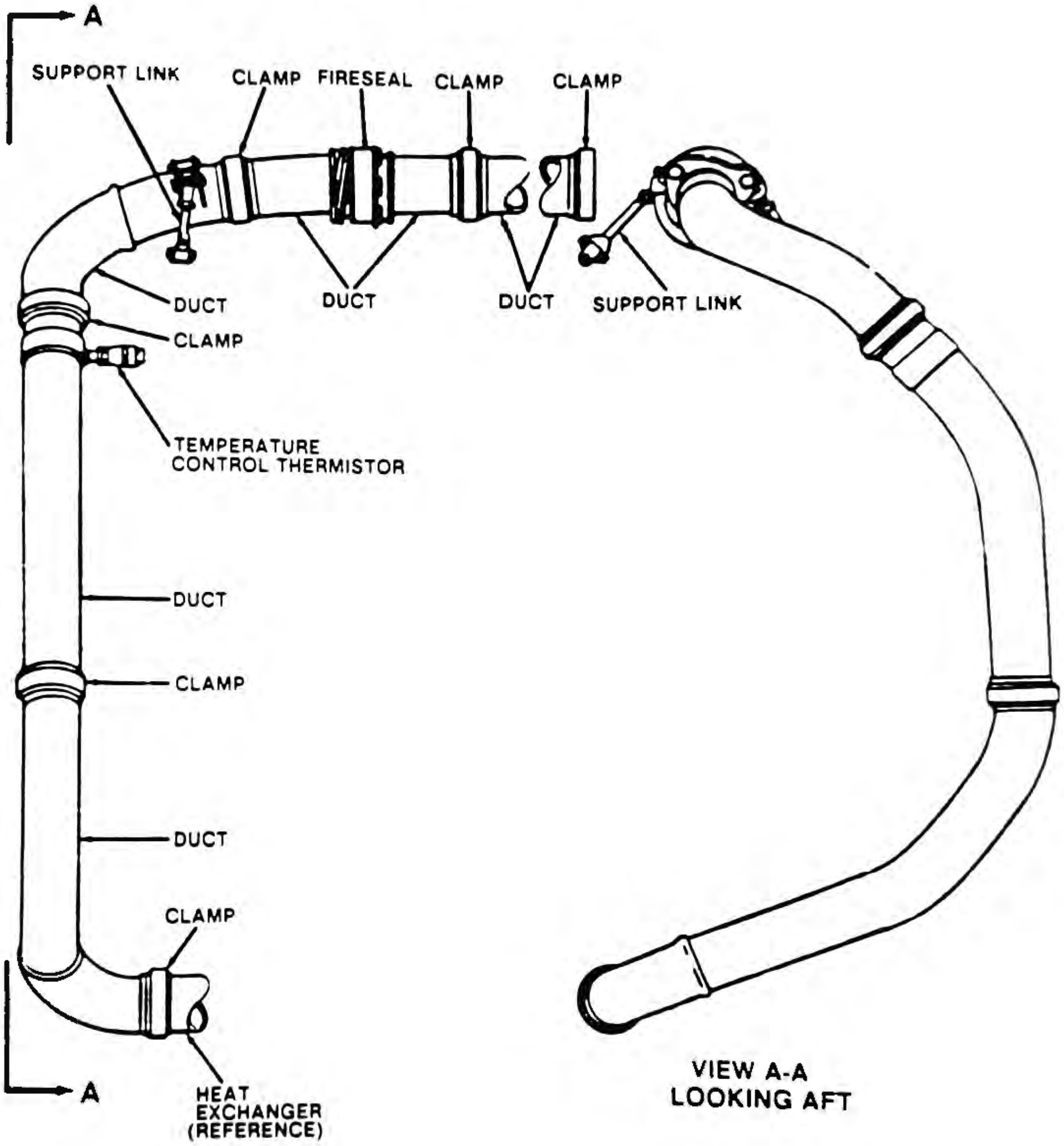
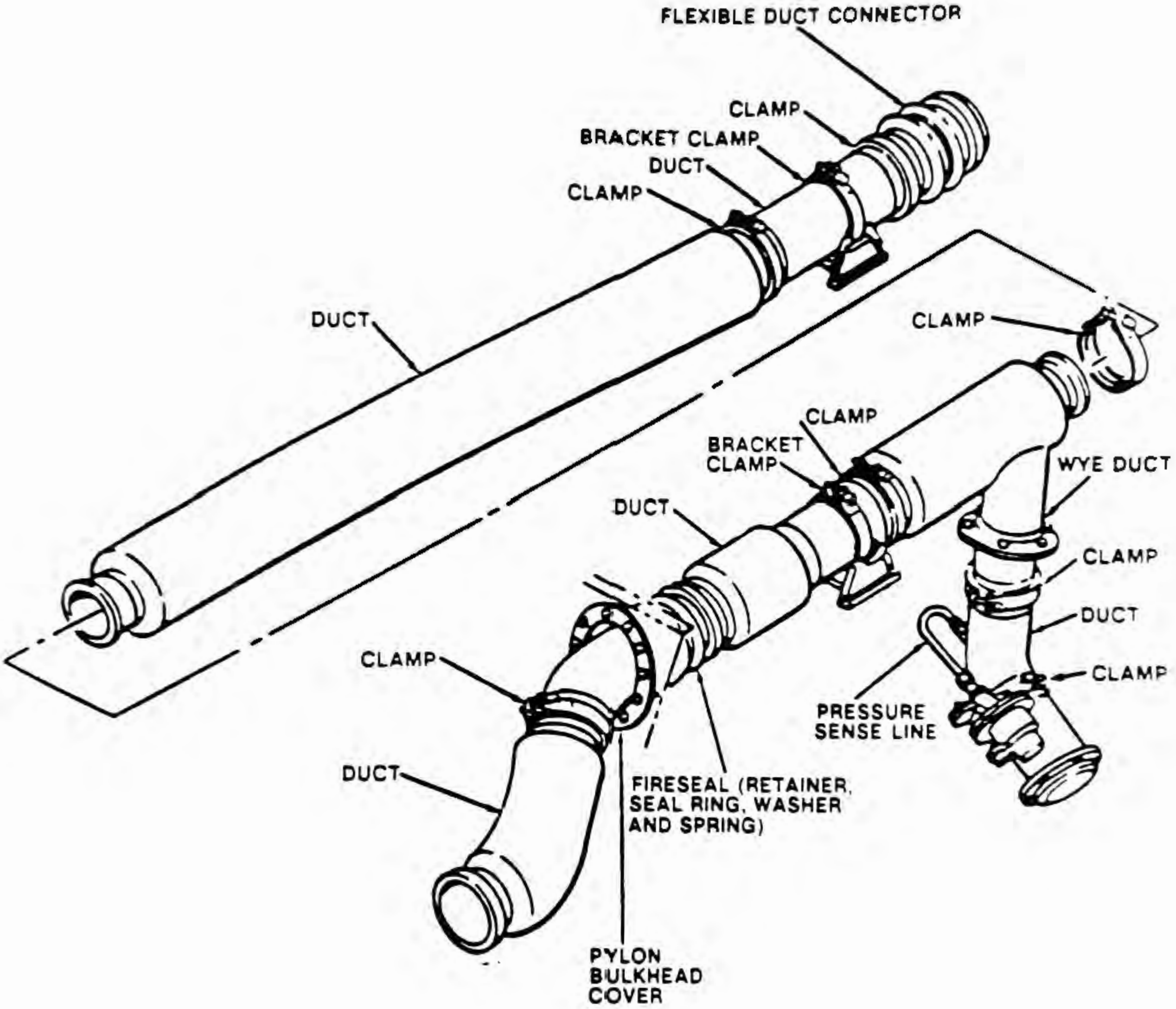
Figure 36-8



HEAT EXCHANGER OUTLET DUCTS

FTX80463

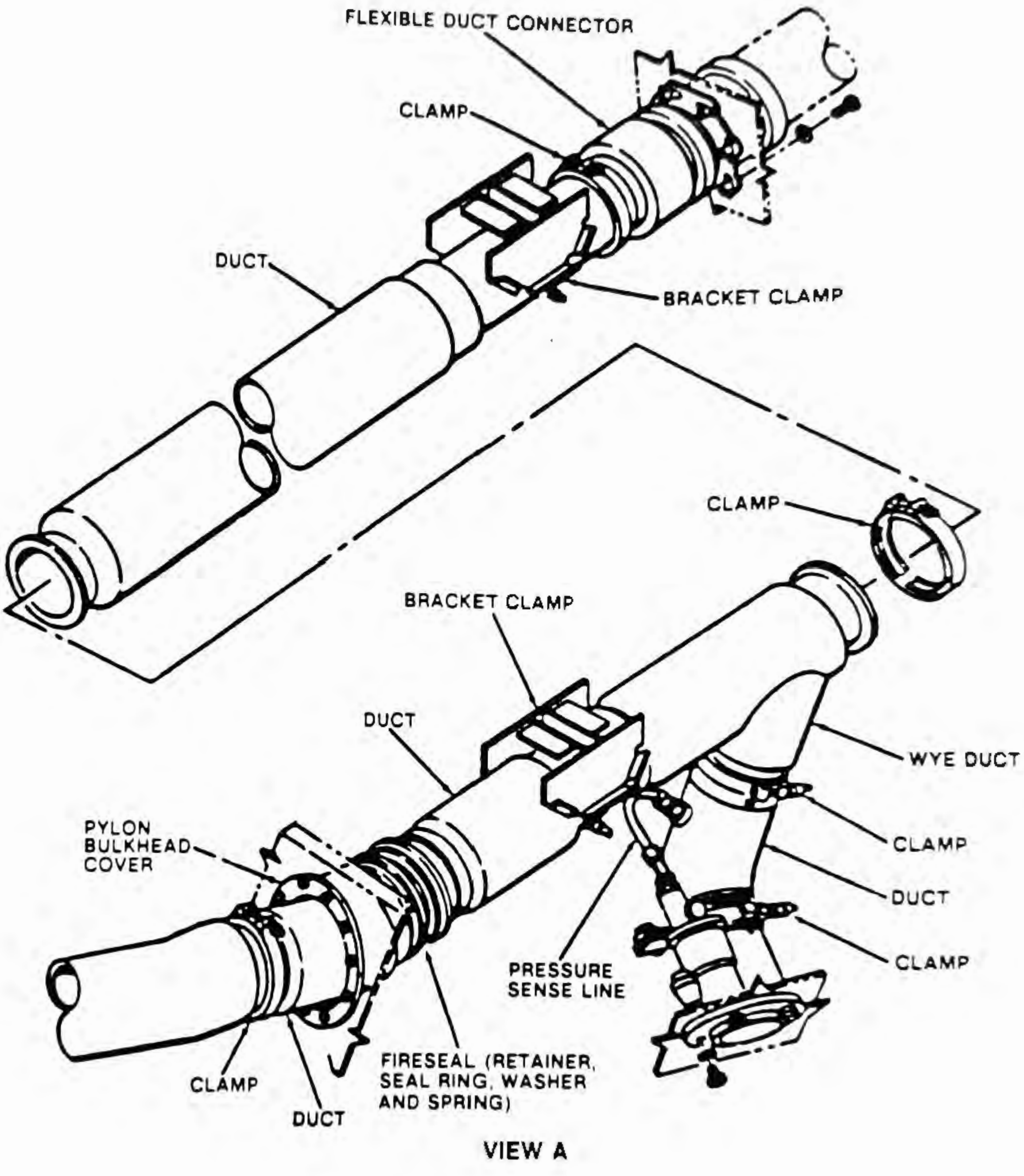
Figure 36-9



INBOARD PYLON DUCTS

FTX80465

Figure 36-10



OUTBOARD PYLON DUCTS

FTX80464

Figure 36-11

(8) Ground Source Connector (See Figure 36-12)

(a) The fuselage nose ground pneumatic connector is a nipple-type connector, used to attach a pneumatic power source to the pneumatic manifold. It also acts as a check valve to prevent air in the pneumatic manifold from discharging overboard. The ground pneumatic connector is installed in the rain removal duct, which connects to the pneumatic manifold. The connector is located on the lower fuselage centerline aft of the radome.

(b) When a ground external source of air pressure is connected to the ground pneumatic connector, the valve opens. This allows air to flow into the pneumatic manifold. The check valve is held closed when the pneumatic system is pressurized with engine bleed air.

5. Pressure Regulation and Control

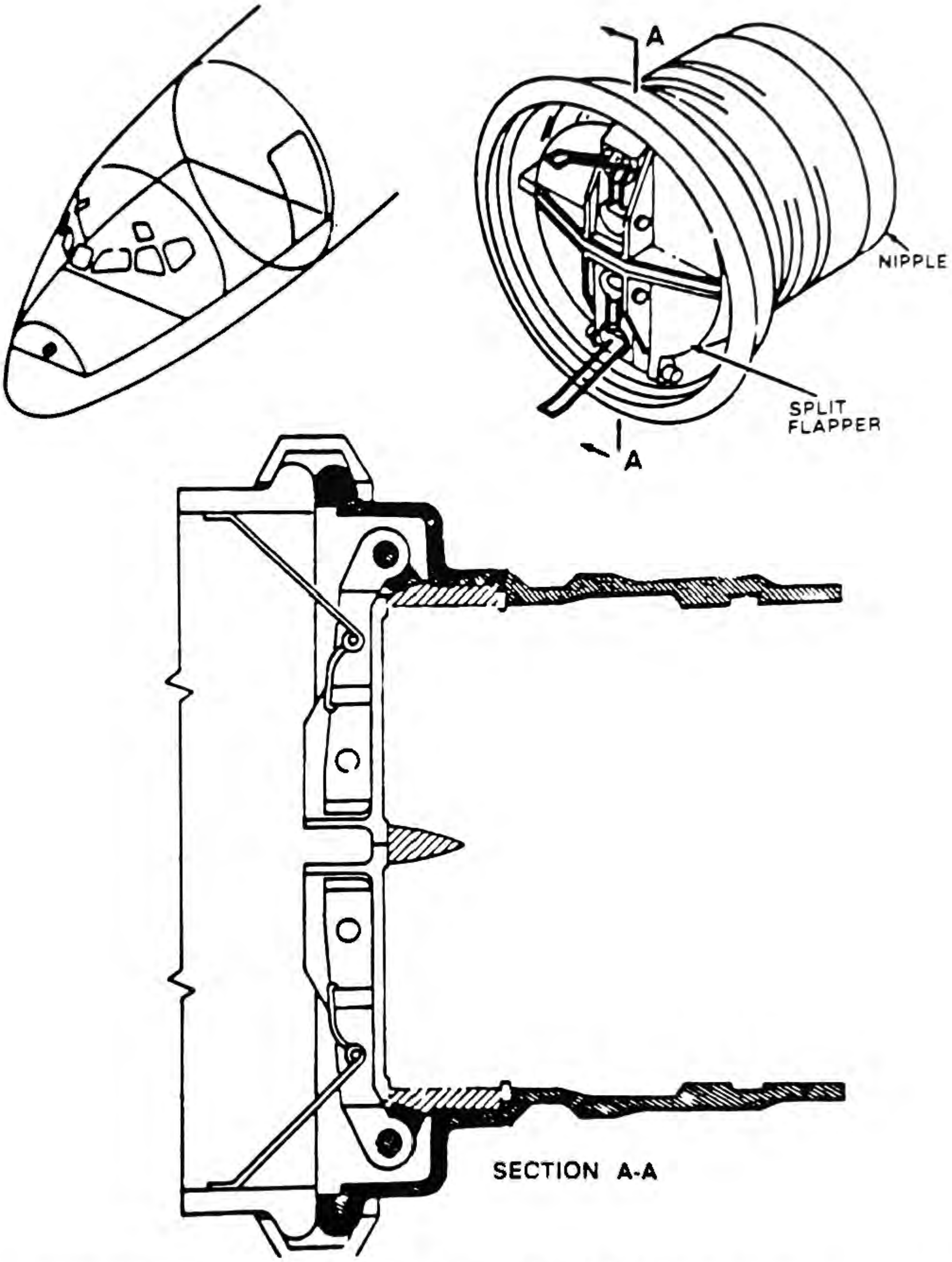
A. General

The pressure regulation and control of the pneumatic system is obtained by the use of components that permit selection of the pressurized air source that protect from overpressure, that regulate the pressure, and that shutoff the system. A crossfeed valve is provided to connect or isolate the left and right sections of the system. The control of ground source air is limited to overpressure control and distribution.

B. Description

(1) Low-pressure pneumatic shutoff switches (See Figures 36-13 and 36-14)

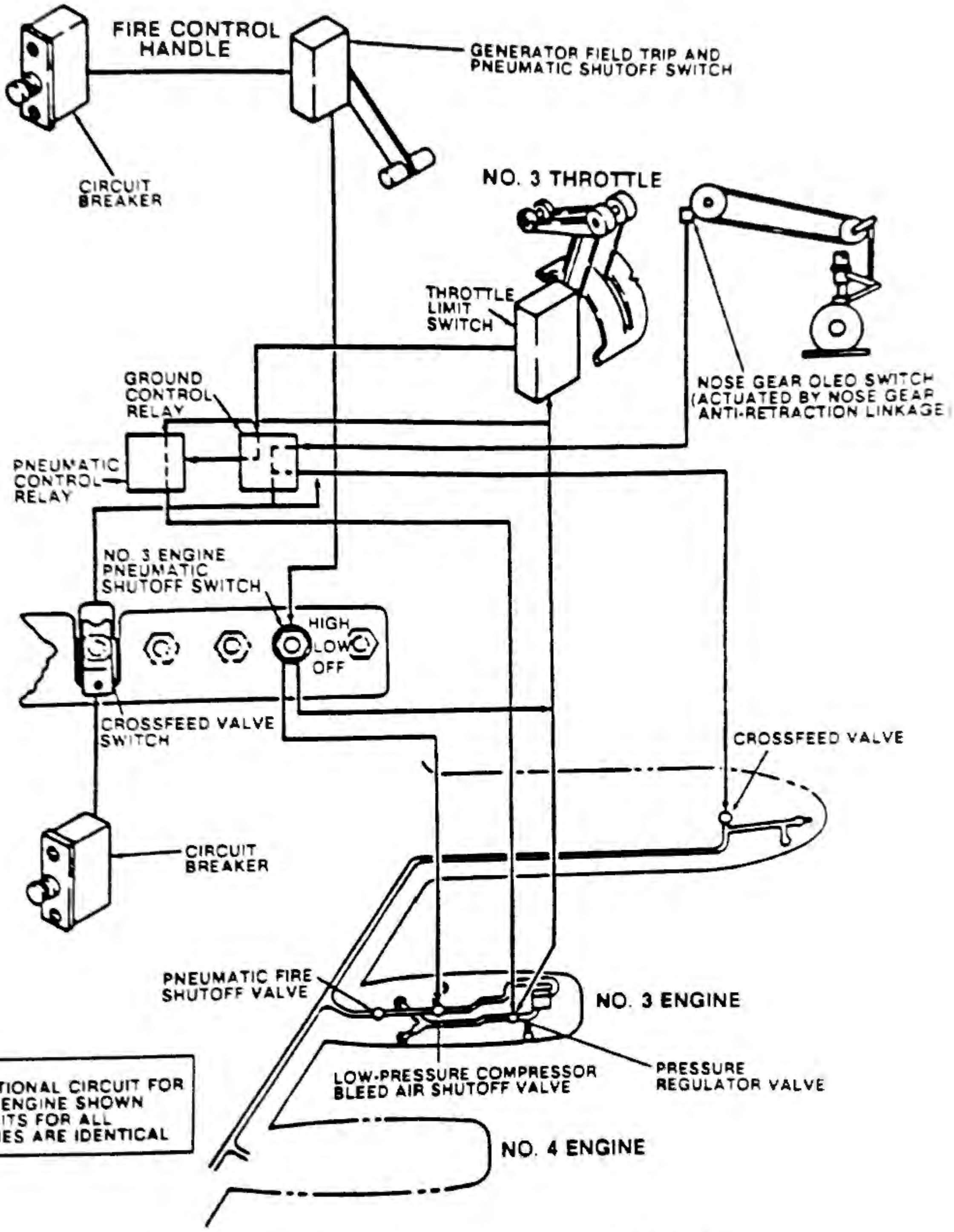
Shutoff switches, one for each engine, are located on the systems engineer's control panel. Switch positions of high, low, and off permit selection of engine bleed air from the high-pressure compressor, low-pressure compressor, or shutoff all engine bleed air. During ground operations, the switch high position can be overriden by a control circuit, which is activated by the throttle limit switches. The limit switches, one for each throttle, are located in the pilot's control pedestal. When activated, the control circuit selects low-pressure compressor bleed air when the corresponding throttle is advanced approximately 18 degrees (1 9/16 inch) from the idle stop.



FUSELAGE NOSE GROUND PNEUMATIC CONNECTOR

FTX80466

Figure 36-12

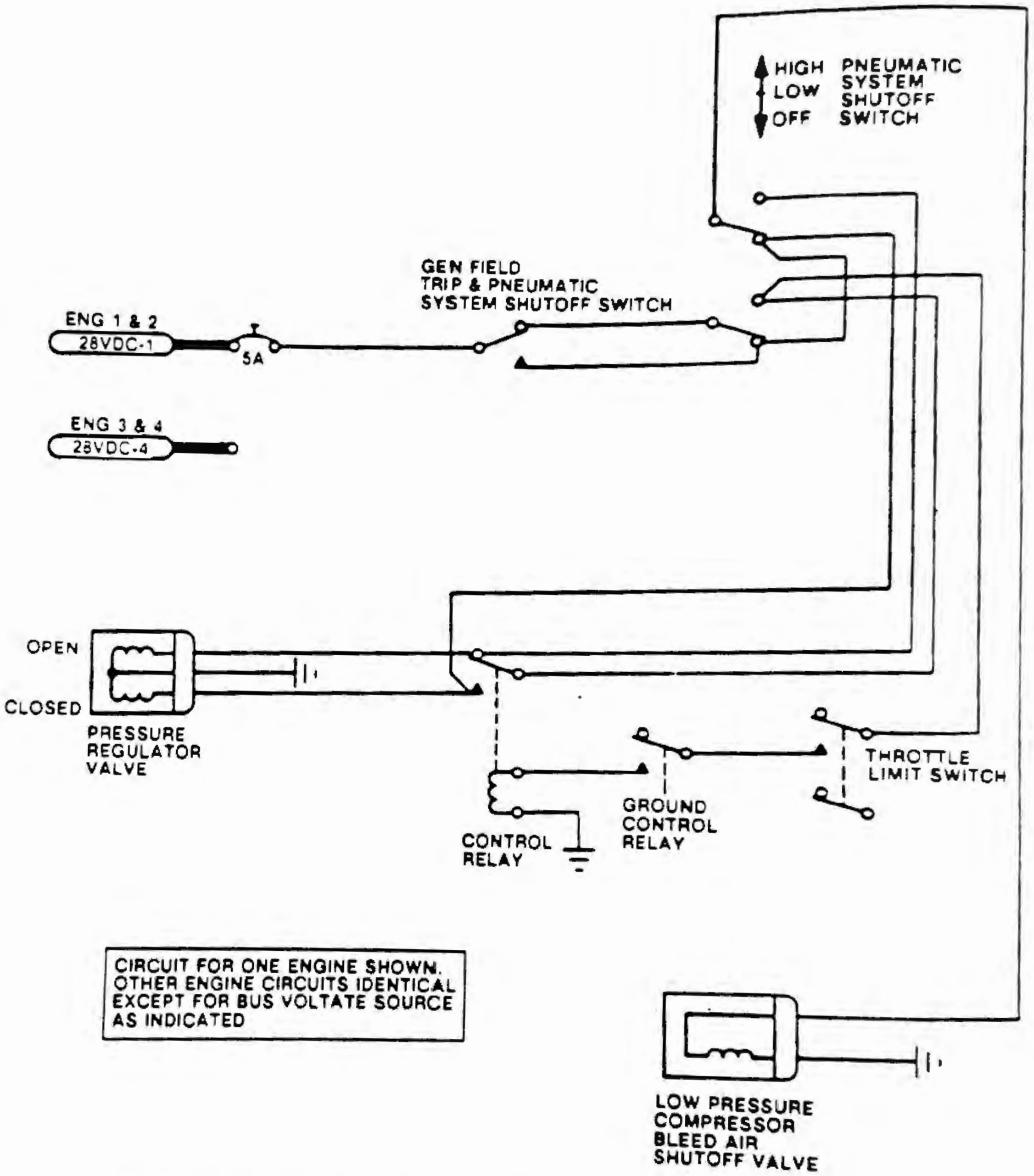

FIRE CONTROL HANDLE
GENERATOR FIELD TRIP AND PNEUMATIC SHUTOFF SWITCH
CIRCUIT BREAKER
NO. 3 THROTTLE
THROTTLE LIMIT SWITCH
NOSE GEAR OLEO SWITCH (ACTUATED BY NOSE GEAR ANTI-RETRACTION LINKAGE)
GROUND CONTROL RELAY
PNEUMATIC CONTROL RELAY
NO. 3 ENGINE PNEUMATIC SHUTOFF SWITCH
HIGH
LOW
OFF
CROSSFEED VALVE SWITCH
CROSSFEED VALVE
CIRCUIT BREAKER
PNEUMATIC FIRE SHUTOFF VALVE
NO. 3 ENGINE
LOW-PRESSURE COMPRESSOR BLEED AIR SHUTOFF VALVE
PRESSURE REGULATOR VALVE
NO. 4 ENGINE

NOTE
FUNCTIONAL CIRCUIT FOR NO. 3 ENGINE SHOWN CIRCUITS FOR ALL ENGINES ARE IDENTICAL

PNEUMATIC CONTROL FUNCTIONAL DIAGRAM

FTX80467

Figure 36-13



CIRCUIT FOR ONE ENGINE SHOWN. OTHER ENGINE CIRCUITS IDENTICAL EXCEPT FOR BUS VOLTATE SOURCE AS INDICATED

PRESSURE REGULATION AND CONTROL ELECTRICAL SCHEMATIC

FTX80468

Figure 36-14

(2) Pressure regulator valve (See Figure 36-15)

(a) A pneumatic pressure regulator valve is installed between the high-pressure bleed port duct and the heat exchanger inlet duct of each engine. It is an electrically controlled, pneumatically actuated, butterfly-type valve. An indicator on the exterior of the valve shows the relative position of the butterfly valve. The valve regulates the pressure of the air bled from the high-pressure compressor to 38 (±2) psig. The regulated pressure of 38 psig is reached only when the engine power setting is high enough to give 38 psig, or more, upstream of the valve. At idle power, manifold pressure is low and might fall below 9.5 psig.

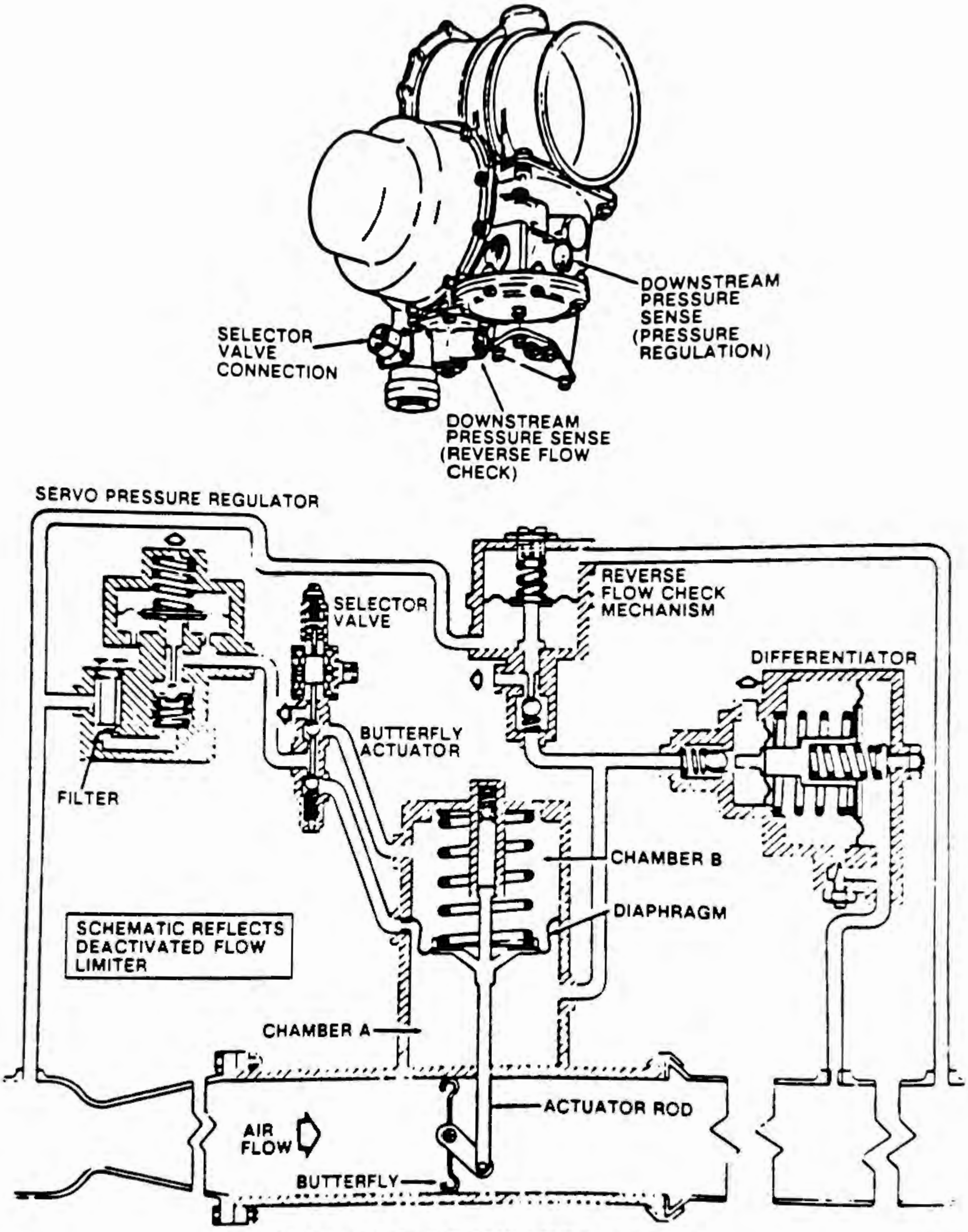
(b) The body of the valve consists of three housings, bolted together. containing the various subassemblies of the valve. The valve has an electrical connector for the solenoid-operated, double-ball selector valve. There are three ports in the valve for connecting 5/16-inch sense lines. One port admits downstream pressure for pressure regulation, one admits downstream pressure for reverse flow check and one admits upstream pressure for servo pressure to actuate the butterfly valve.

(c) The subassemblies contained in the pressure regulator valve and the basic function of each are listed below:

1 A butterfly valve actuator assembly, consisting of a spring-loaded diaphragm, and actuating rod, a butterfly valve, and a cam assembly. this assembly adjusts the butterfly valve to regulate the quantity of air passing through the valve.

2 A servo pressure regulator assembly, consisting of a 40-micron filter and a diaphragm actuated, spring-loaded poppet valve. The pressure regulator controls the air pressure in the butterfly valve actuator assembly.

3 A solenoid-operated, on-off selector valve assembly, consisting of a latching solenoid and a double-ball selector valve. This valve directs air pressure to the butterfly actuator assembly to either open or close the butterfly valve.


DOWNSTREAM PRESSURE SENSE (PRESSURE REGULATION)
SELECTOR VALVE CONNECTION
DOWNSTREAM PRESSURE SENSE (REVERSE FLOW CHECK)
SERVO PRESSURE REGULATOR
SELECTOR VALVE
REVERSE FLOW CHECK MECHANISM
DIFFERENTIATOR
BUTTERFLY ACTUATOR
FILTER
CHAMBER B
DIAPHRAGM
SCHEMATIC REFLECTS DEACTIVATED FLOW LIMITER
CHAMBER A
ACTUATOR ROD
AIR FLOW
BUTTERFLY
FTX80469

PRESSURE REGULATOR VALVE
Figure 36-15

4 A reverse-flow check valve assembly, consisting of a spring-loaded diaphragm and a spring-loaded poppet valve. This valve assembly prevents reverse airflow through the butterfly valve.

5 A differentiator assembly (a rate-type pressure control), consisting of an adjustable orifice, two spring-loaded diaphragms, and a spring-loaded ball valve. The differentiator assembly controls the butterfly valve actuator assembly to regulate air pressure in the pneumatic system to 38 (±2) psig.

(d) The butterfly valve is spring-loaded to the closed position, when the engines are not operating. When the airplane is on the ground with the engines operating and the low-pressure pneumatic shutoff switches are in the low position, the close coil in the solenoid of the selector valve is energized. The close coil will also be energized when the airplane is on the ground with the engines operating, if the low-pressure pneumatic shutoff switches are placed in the high position and the throttle levers are advanced past approximately 18 degrees (1 9/16 inches) or more. The solenoid holds the double-ball selector valve in off position. Air is then routed from the upstream sense port, through the 40-micron filter and to the selector valve. The selector valve directs the air to the top of the diaphragm in the actuator assembly (Chamber B). At the same time, air from the bottom of the diaphragm in the actuator (Chamber A) is vented to atmosphere. Since the pressure in chamber B is greater than the pressure in Chamber A, the butterfly valve remains in the closed position.

(e) When the low-pressure pneumatic shutoff switches are placed in the high position (throttle levers below 18 degrees on the ground, any throttle setting in flight), the open coil in the selector valve solenoid is energized and moves the selector valve to the on position. Upstream air, routed through the filter and the servo pressure regulator, is now directed by the selector valve to Chamber A in the butterfly actuator assembly and Chamber B is vented to atmosphere. The pressure applied to the diaphragm in Chamber A will overcome the spring load. The diaphragm will move up and the actuator linkage will open the butterfly valve.

(f) The servo pressure regulator controls the flow of air to the actuator assembly. The pressure of the air passing through the servo pressure regulator is regulated by a diaphragm actuated poppet valve. the poppet valve varies the opening through which the air must flow to get to the actuator assembly. The poppet valve is controlled by a diaphragm which divides the upper portion of the pressure regulator into two chambers. Some of the air passing through the poppet valve is bled through an orifice into the lower chamber. This applies upstream air pressure to the under side of the diaphragm. An orifice in the body of the diaphragm allows air to bleed into the upper chamber, which is vented to atmosphere. When the pressure in the lower chamber of the pressure regulator increases, the diaphragm moves up. The poppet valve is moved to decrease the size of the opening the air must pass through, thereby decreasing the air pressure in the chambers of the actuator assembly. The poppet valve will seek a balanced position due to the bleed air passing into the upper chamber through the orifice in the diaphragm.

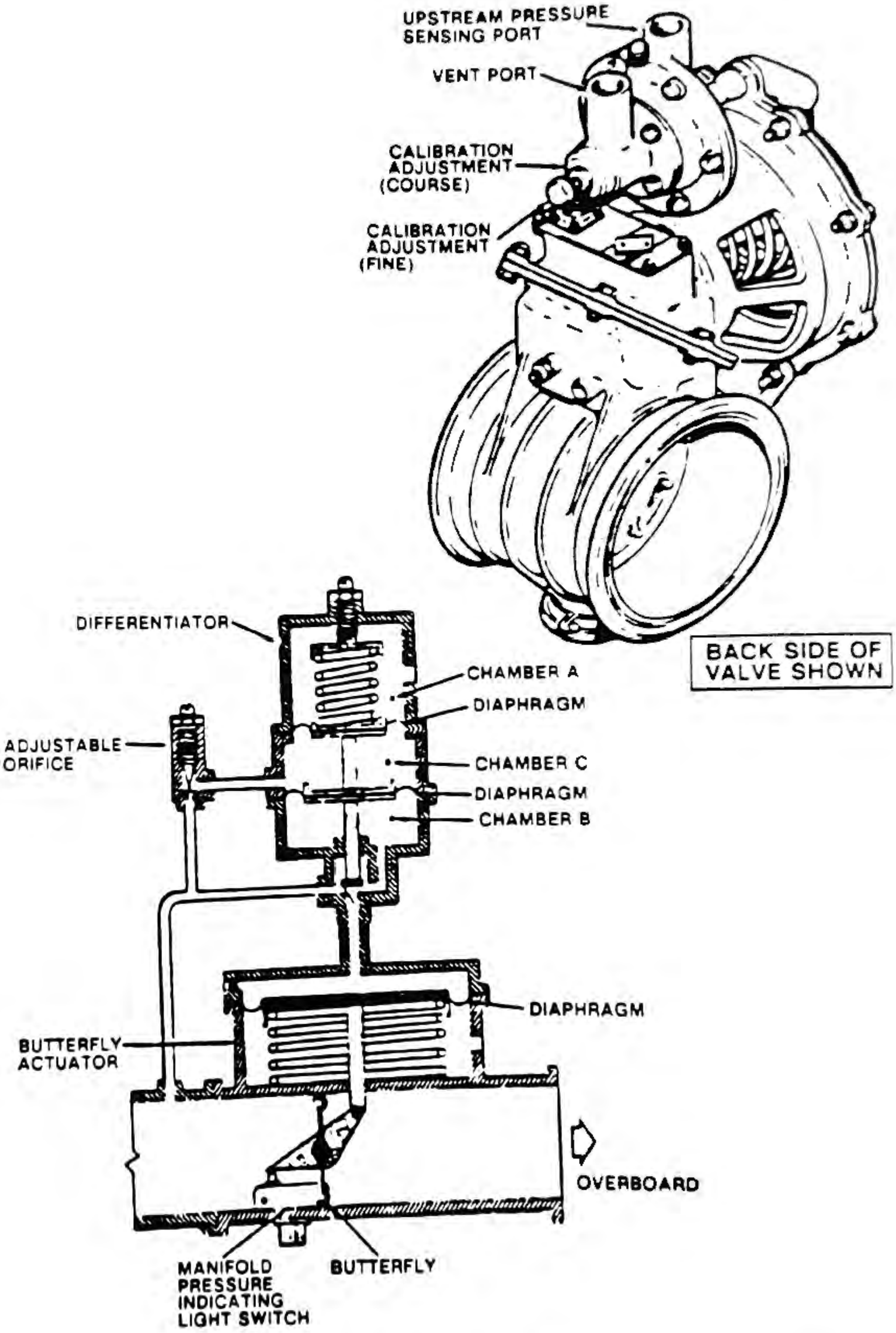
(g) When the actuator opens the butterfly valve, the downstream air pressure increases. Some of the downstream air is routed to the upper chamber of the differentiator assembly. At a predetermined downstream pressure level, the ball valve in the differentiator opens and air is bled from Chamber A in the actuator assembly and vented to atmosphere. The butterfly valve is positioned to maintain a regulated downstream pressure by the force balance of the pressure in Chamber A applied to the actuator diaphragm, which is opposed by the actuator spring. Two diaphragms, one large and one small, divide the differentiator into three chambers. Downstream air pressure is routed to the upper chamber, through an adjustable orifice, and into the middle chamber. The lower chamber is vented to atmosphere. When there is a sudden increase in downstream pressure, pressure builds up in the upper chamber first. The large diaphragm moves down, unseating the ball valve. Air will be bled from Chamber A in the actuator assembly at a rate proportional to the rate of increase in downstream pressure. this will cause the butterfly valve to close sufficiently to reduce the downstream pressure. Should the downstream pressure suddenly decrease while the ball valve is open, pressure would be reduced in the upper chamber first because of the restricting orifice. The pressure in the middle chamber would act upon the large diaphragm to reduce quickly the rate at which air is bled from Chamber A. A gradual increase in downstream pressure would cause the pressure in the upper and middle chambers to increase at approximately the same rate. Since the pressures in the upper and middle chambers will be equal, the large diaphragm will not transmit movement to the ball valve. The position of the ball valve would then be controlled by the small diaphragm, which produces smaller motions of the ball valve, thereby changing the pressure in Chamber A slowly until a state of balance is established.

(h) The reverse flow check valve is divided into two chambers by a diaphragm. Upstream air pressure is routed to the lower chamber and downstream air pressure is routed to the upper chamber. If the upstream pressure falls within 0.25 psig or less of the downstream pressure, spring force moves the diaphragm down. The diaphragm unseats a poppet valve which allows air from Chamber A in the actuator asembly to be vented to atmosphere. This causes the butterfly valve to close, preventing reverse airflow through the valve.

(3) Pneumatic Pressure Relief Valve (See Figure 36-16)

(a) A pressure relief valve is installed downstream of the pressure regulator on each engine. The valve is a differential pressure butterfly-type valve, which prevents overpressurizing the pneumatic system by venting to atmosphere upstream pressure in excess of 45.5 (±2) psig. During system surges, the valve might operate momentarily until the pressure regulator adjusts to the change in demand. During ground operation, the valve normally relieves at 45.5 to 47 psig. Over a wide range of conditions in flight, the relief valve limits system pressure from a minimum of 44.5 psig to a maximum of 49 psig, should the pressure regulator be inoperative. when the valve opens, a lever attached to the actuating mechanism actuates an electrical switch which causes an indicating light on the system engineer's control panel to come on.

(b) The valve has two main housings, bolted together, which contain the valve subassemblies. An electrical connector is provided for the internal switch that activates the indicating light circuit. A vent port and a pressure sensing port are also provided.



PRESSURE RELIEF VALVE

FTX80470

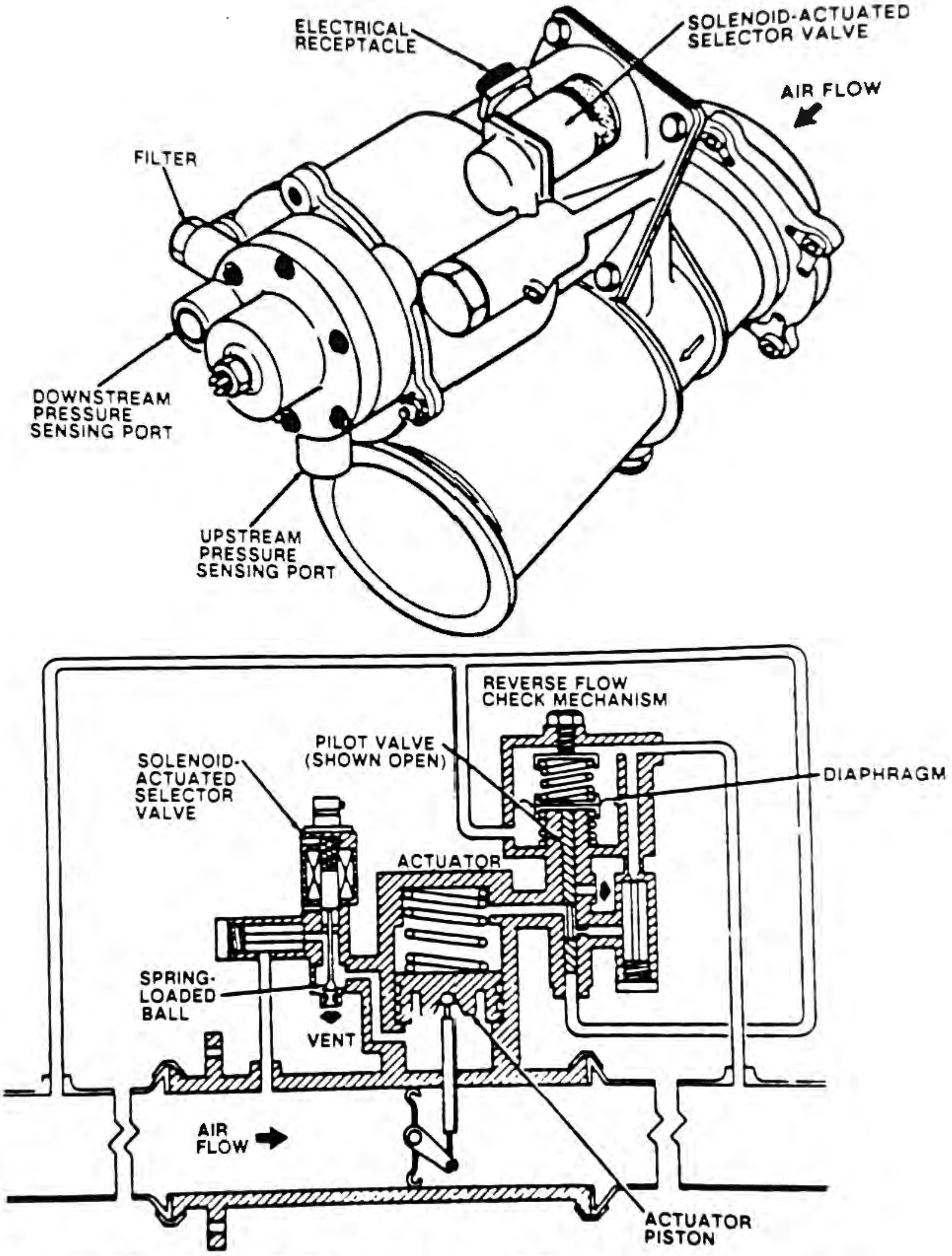
Figure 36-16

(c) The relief valve consists of a differentiator and a butterfly actuator. The differentiator includes two spring-loaded diaphragms, an adjustable orifice, a bimetallic temperature compensator, and a poppet valve. The butterfly actuator contains a spring-loaded diaphragm, an actuating rod, a butterfly, a cam, and an electrical switch.

(d) The butterfly is spring-loaded to the closed position. The differentiator senses upstream air pressure through an external port in the valve body. the differentiator is divided into three chambers by two diaphragms, one large and one small. The upstream air is directed to the lower chamber (Chamber B) and through an adjustable orifice into the middle chamber (Chamber C). the upper chamber (Chamber A) is vented to atmosphere. When upstream air is regulated to 38 (±2) psig or less, the relief valve is closed. If upstream pressure suddenly increases to 45.5 to 47 psig or more, pressure will build up in Chamber B first. The large diaphragm instantly moves up and unseats the poppet valve, which admits pressure to the top of the actuator diaphragm at a rate proportional to the rate of increase of upstream pressure. The pressure overcomes the spring force and moves the actuator diaphragm down, which opens the butterfly to vent upstream pressure to atmosphere. If upstream pressure decreases suddenly while the poppet is open, pressure in Chamber B drops rapidly. Pressure in Chamber C then acts upon the large diaphragm to quickly close the poppet and reduce the rate at which upstream pressure is vented.

(e) A gradual increase in upstream pressure causes the pressure in Chambers B and C to increase at approximately the same rate. Since the pressure in Chambers B and C are equal, the large diaphragm does not transmit movement to the poppet valve.. The position of the poppet valve is then controlled by the small diaphragm, which produces less movement. The pressure against the bottom of the actuator diaphragm increases slowly until a balanced condition exists. When the upstream pressure drops below 45.5 to 45 psig, air to the top of the actuator diaphragm is shut off and is vented to atmosphere. Spring force then closes the butterfly. The rate-type of control has a stabilizing effect on valve performance.

(4) Low-Pressure Compressor Bleed Air Valve (See Figure 36-17)


ELECTRICAL RECEPTACLE
SOLENOID-ACTUATED SELECTOR VALVE
AIR FLOW
FILTER
DOWNSTREAM PRESSURE SENSING PORT
UPSTREAM PRESSURE SENSING PORT
REVERSE FLOW CHECK MECHANISM
PILOT VALVE (SHOWN OPEN)
SOLENOID-ACTUATED SELECTOR VALVE
DIAPHRAGM
ACTUATOR
SPRING-LOADED BALL
VENT
AIR FLOW
ACTUATOR PISTON

LOW-PRESSURE COMPRESSOR BLEED AIR SHUTOFF VALVE FTX80471

Figure 36-17

(a) A low-pressure bleed air valve is installed between the low-pressure bleed port duct of each engine and the pylon ducting. It is an electrically controlled, pneumatically actuated butterfly-type valve. the valve operates to supply bleed air from low-pressure compressors to the pneumatic system during takeoff or during engine runup on the ground. It also acts to prevent reverse airflow.

(b) The body of the valve consists of a butterfly valve housing and an actuator housing bolted together. The valve housing has a clamp-type mounting flange at each end. An integral mounting flange is provided near the upstream side of the valve for attaching the valve to pylon structure. An electrical receptacle is installed on the top of the actuator housing. The valve has two external pressure sensing ports, one for upstream pressure and one for downstream pressure. An arrow, located next to the electrical receptacle, indicates direction of airflow.

(c) The valve assembly includes the following subassemblies:

1 A butterfly valve actuator assembly consisting of a spring-loaded piston, actuating linkage, and a butterfly valve.

2 A solenoid operated, on-off selector valve assembly, consisting of a solenoid and a spring-loaded ball valve.

3 A reverse-flow check valve assembly, consisting of a spring-loaded diaphragm, a diaphragm-actuated pilot valve, and a 10-micron filter.

(d) The butterfly valve is spring-loaded to the closed position. However, any upstream air pressure opens the valve, except when the solenoid is energized. During ground operations, the coil of the solenoid is deenergized when the throttle levers are advanced past approximately 18 degrees (1 9/16 inches), with the low-pressure pneumatic shutoff switches in the high position. When the solenoid is deenergized, air from the upstream pressure-sensing port, having passed through the 40-micron filter, is routed through the ball valve to the open side of the actuator piston. when the pneumatic shutoff switches are in the low position, the solenoid is deenergized and the valve opens (assuming engine operation). Pressure on the piston overcomes spring force and the piston moves, opening the butterfly valve through linkage.

(e) In flight, when the low-pressure pneumatic shutoff switches are in the high positions, the solenoid is energized and the valve is closed. The solenoid is also energized and the valve closed on the ground when the pneumatic shutoff switches are in the high positions and the throttles are positioned between the idle stop and a point approximately 18 degrees (1 9/16 inches) forward of the idle stop. The spring in the solenoid moves the ball valve to close the upstream pressure port and to vent the open side of the actuator piston to atmosphere. The spring in the actuator assembly returns the piston, causing the butterfly valve to close.

(f) When downstream pressure exceeds upstream pressure, the reverse-flow check mechanism closes the valve (solenoid either energized or deenergized). The reverse-flow check valve assembly is divided into two chambers by the spring-loaded diaphragm. Upstream pressure is routed to one side of the diaphragm and downstream pressure is routed to the other. When upstream pressure is greater than downstream pressure by at least 0.25 psig, the pilot valve is moved to the closed position by the force applied to the diaphragm by the upstream pressure and the spring. The close side of the actuator piston is then vented to atmosphere. If the coil of the solenoid is deenergized, the butterfly valve will open, remaining open until the solenoid is energized. If the upstream press falls to a value of 0.125 psig, or less, greater than the downstream pressure, the diaphragm will move the pilot valve to completely close the vent. Downstream pressure and spring force acting on the close side of the piston will overcome the upstream pressure acting on the open side. The butterfly valve will close and remain closed regardless of the position of the solenoid-operated selector valve. this action prevents reverse flow through the valve.

(5) Engine Pneumatic Fire Shutoff Valve (See Figure 36-18)

(a) An engine pneumatic fire shutoff valve is installed in each pylon between the pylon ducts and the pneumatic manifold. It is a cable-operated, butterfly-type valve. When closed, the valve prevents an engine fire from spreading through the pneumatic ducts by isolating the pylon ducts from the pneumatic manifold.

(b) The valve housing has a clamp-type mounting flange at each end and a bolt-type mounting flange near the valve inlet. An external pointer indicates the position of the butterfly valve and provides an index for valve rigging. Direction of airflow is indicated by an arrow on either side of the valve housing. An overcentering lever assembly at the bottom of the valve housing spring loads the valve to either the open or closed positions.

(c) The valve assembly includes the following components:

1 A radially serrated, pulley-locking hub

2 A cam-and-shaft assembly, which is splined to the pulley-locking hub

3 A cam follower assembly, consisting of a cam follower, two rollers, a lever, and a cam stop pin

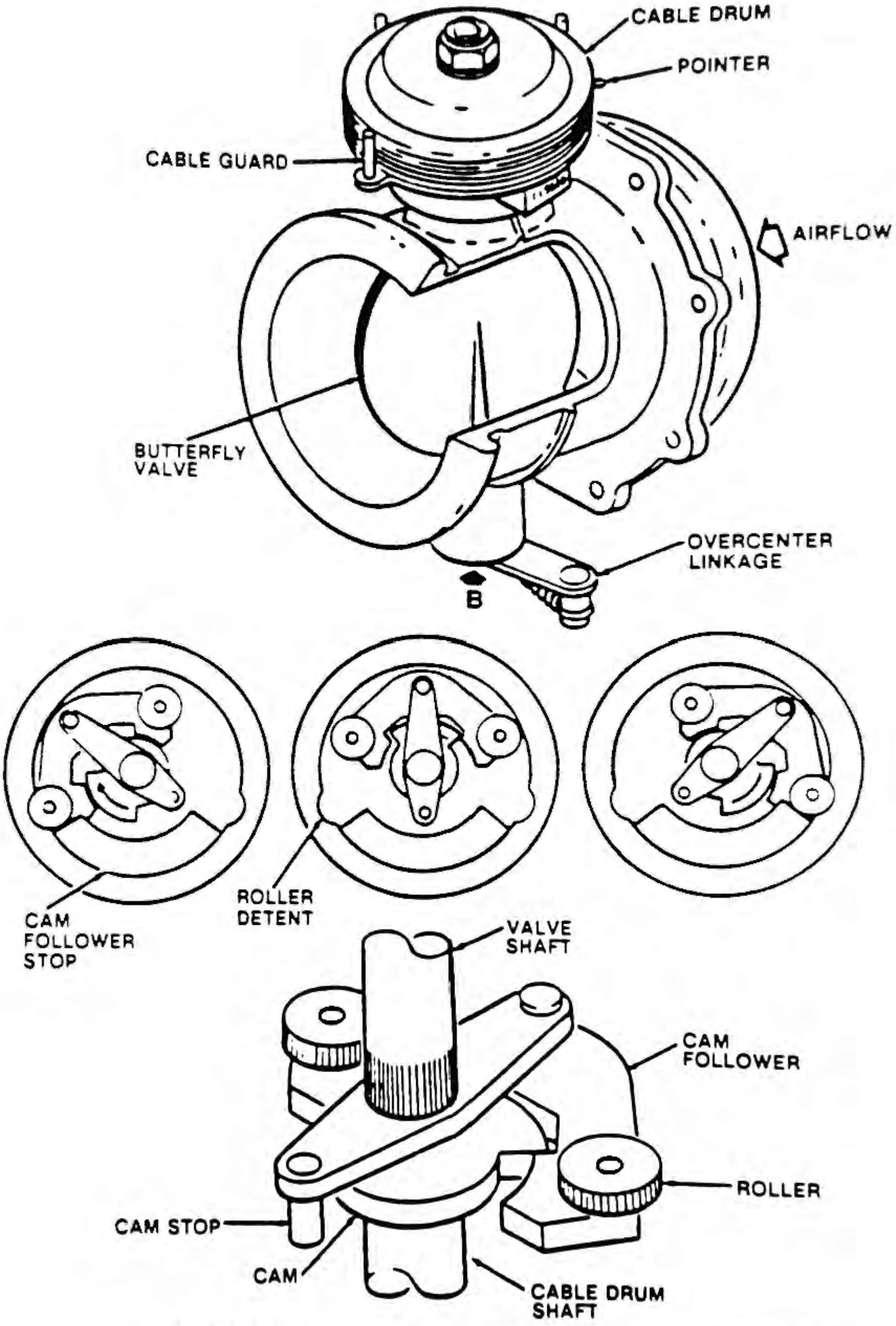
4 A cam follower stop

5 A butterfly valve

6 A butterfly valve shaft, which is splined to the cam follower assembly, to the butterfly valve, and to the overcentering lever assembly

7 An overcentering lever assembly, consisting of lever, an anchor pin, and a spring.

(d) Operation of the valve is controlled, through cables, by the associated fire shutoff handle located aft of the overhead switch panel. A cable drum is installed on the valve so that serrations in the cable drum mesh with serrations in the pulley-locking hub. When a fire shutoff handle is actuated, the cable rotates the cable drum at the valve assembly, which in turn rotates the pulley-locking hub. When a fire shutoff handle is actuated, the cable rotates the



ENGINE PNEUMATIC FIRE SHUTOFF VALVE

FTX80472

Figure 36-18

cable drum at the valve assembly, which in turn rotates the pulley-locking hub. The hub turns the cam-and-shaft until the cam engages a slot in the cam follower assembly. The cam follower moves with the cam, causing the butterfly valve shaft to rotate. When the butterfly valve has reached the closed (or open) position, the cam follower strikes the cam follower stop and the leading roller falls into a recess in the valve housing. The cam follower swivels to permit the cam to disengage the slot. Further rotation of the cable drum does not cause further movement of the butterfly valve, although the cam might continue to travel until striking the cam stop pin. the cable drum and pulley-locking hub can rotate 186 degrees, divided as follows:

1 Pretravel - 10 degrees, while the valve is in the open position

2 Operating Travel - 90 degrees, while the valve is closing

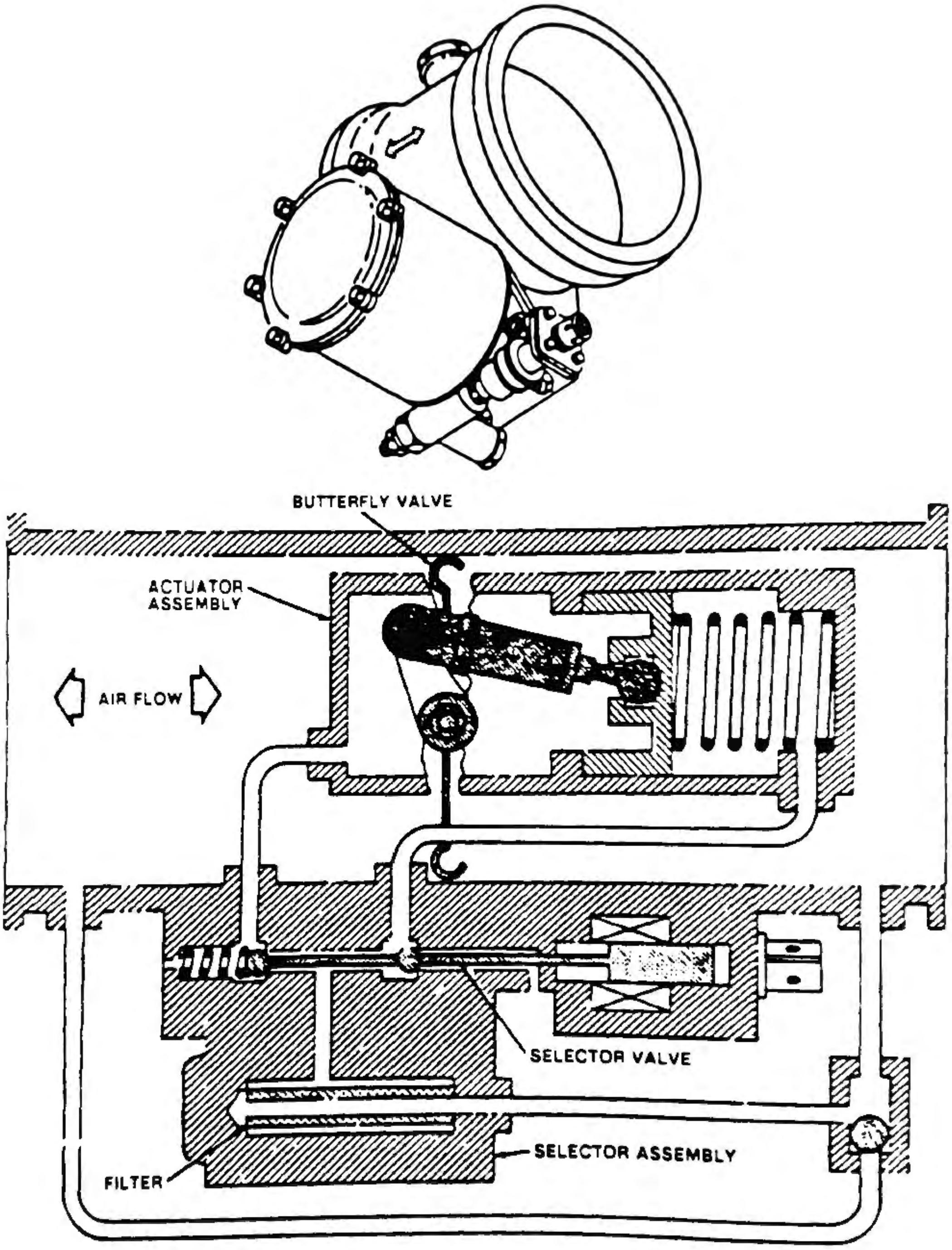
3 Overtravel - 86 degrees, while the valve is in the closed position

(e) The valve can be rigged without removing cable tension by loosening the nut attaching the cable drum and turning the pulley-locking hub.

(6) Manifold Crossfeed Valve (See Figures 36-19 and 36-20)

(a) A pneumatic manifold crossfeed valve is installed between the left and right sections of the pneumatic manifold on the centerline of the fuselage near the aft bulkhead of the cabin compressor compartment. It is an electrically controlled, pneumatically actuated butterfly-type valve. The valve operates to isolate the left and right sections of the pneumatic sections manifold (when closed) or to permit airflow between the left and right sections (when open).

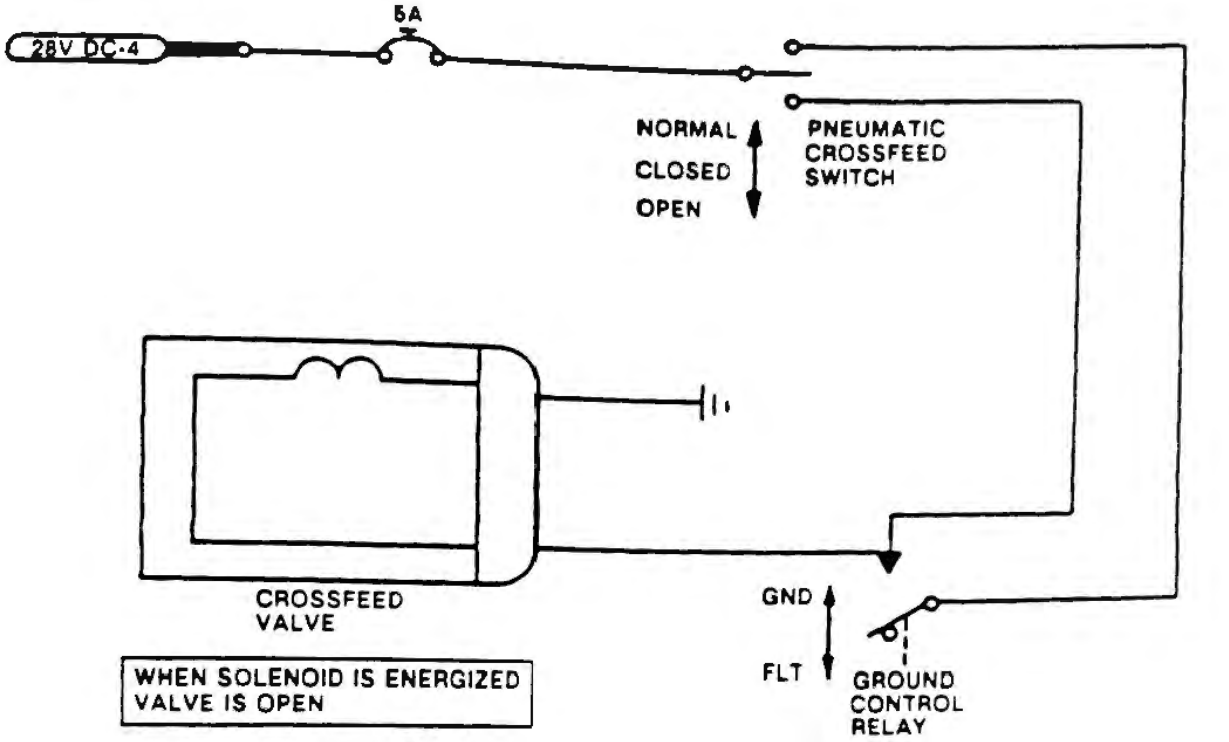
(b) The body of the valve consists of a butterfly valve housing and an actuator housing bolted together. The valve has a clamp-type mounting flange at either end and a triangular mounting lug opposite the actuator housing. An electrical connector and a solenoid-controlled selector valve are located on the actuator housing. A butterfly position indicator located on the actuator housing gives a mechanical indication of butterfly position.



MANIFOLD CROSSFEED VALVE

Figure 36-19

FTX80473



CROSSFEED VALVE ELECTRICAL CIRCUIT SCHEMATIC

FTX80474

Figure 36-20

(c) The valve assembly includes the following subassemblies:

1 A butterfly-valve actuator assembly, consisting of a spring-loaded piston, actuating linkage, and a butterfly valve

2 A solenoid-operated selector valve assembly, consisting of a solenoid, a spring-loaded double-ball valve, a filter, and a ball check valve.

(d) With air pressure on either side of the butterfly valve and the solenoid deenergized, the double-ball selector valve is spring-loaded to the closed position. Air pressure is then routed from either of the pressure sense ports, through the ball check valve and filter, to the close side of the piston. The open side of the piston is vented to atmosphere. The butterfly valve is held closed by the combination of air pressure and spring force. When the coil of the solenoid is energized, the selector valve is actuated. air is then routed from the pressure sense ports, through the ball check valve and filter, to the open side of the piston. The close side of the piston is vented to atmosphere. The piston moves against the spring, opening the butterfly valve through linkage. The ball check valve allows air pressure from either side of the pneumatic manifold to operate the valve.

(e) The crossfeed valve control circuit includes a guarded switch, contacts of the No. 4 engine ground control relay and the solenoid in the crossfeed valve. During normal operation the crossfeed valve switch is placed in the normal position and opening and closing of the valve is controlled through the action of the ground control relay. With the airplane on the ground, the ground control relay is energized, electrical power is supplied to energize the crossfeed valve solenoid and the valve is open. If the left and right side pneumatic systems need to be isolated, placing the crossfeed valve switch in the closed position interrupts the power to the solenoid and the valve closes. Any time the solenoid is deenergized, the crossfeed valve is closed.

During flight the ground control relay is deenergized, power is not supplied to the solenoid and the crossfeed valve is closed. Placing the crossfeed valve switch in the open position supplies power directly to the crossfeed valve solenoid and the valve opens.

6. Temperature Regulation and Control

A. General

(1) The temperature control system regulates the manifold air temperature by controlling the flow of cooling ram air through the engine bleed air heat exchangers located in each engine nacelle nose section. This is done automatically by adjustment of the position of the heat exchanger exhaust flap.

(2) The temperature control system consists of a temperature control amplifier, a temperature thermistor, and an engine bleed air heat exchanger actuator for each engine. The temperature of the manifold air is regulated at 446 (±14) °F (230 ±8) °C as it passes through the heat exchangers.

B. Description

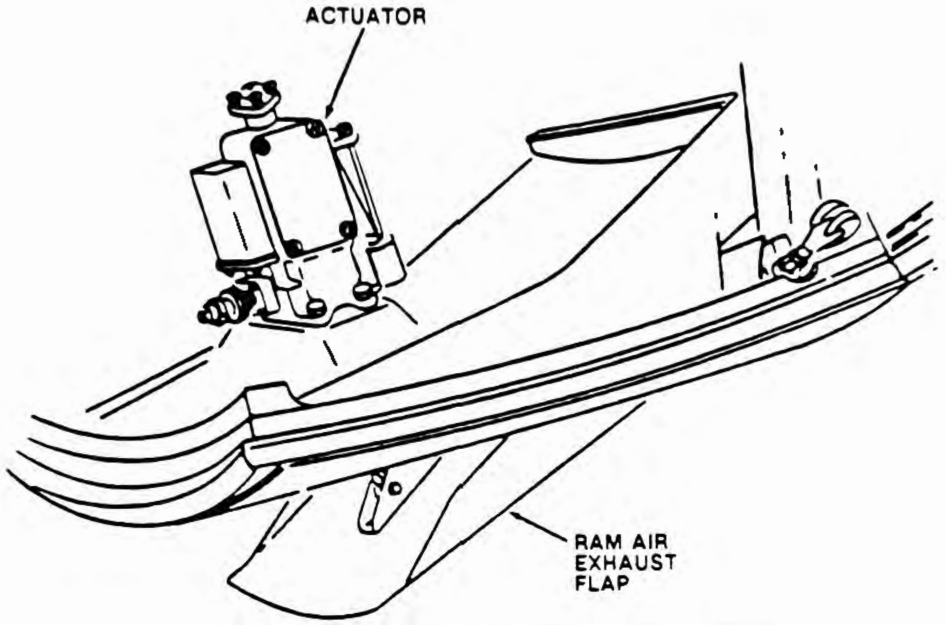
(1) Temperature Control Amplifiers ·

Each of the temperature control amplifiers consist of two magnetic amplifiers and two relays. One amplifier and relay circuit functions to energize the actuator to open the heat exchanger exhaust flap, while the other functions to close the flap. Limit switches stop the actuator motor when the flap reaches the fully opened or closed position. The temperature thermistor, located in the duct downstream of each heat exchanger, acts as a variable-resistance leg of the magnetic amplifier bridge circuit.

(2) Heat Exchange Flap and Actuator (See Figure 36-21)

(a) An engine bleed air heat exchanger actuator (electric motor driven) is installed on the lower side of each nacelle. Each actuator is operated by the respective temperature control amplifier to regulate the temperature of the air downstream of the engine bleed air heat exchanger. A thermoswitch protects the actuator motor from overheating.

(b) This actuator operates the flap of the heat exchanger ram air exhaust.



HEAT EXCHANGER RAM AIR EXHAUST

FTX80475

Figure 36-21

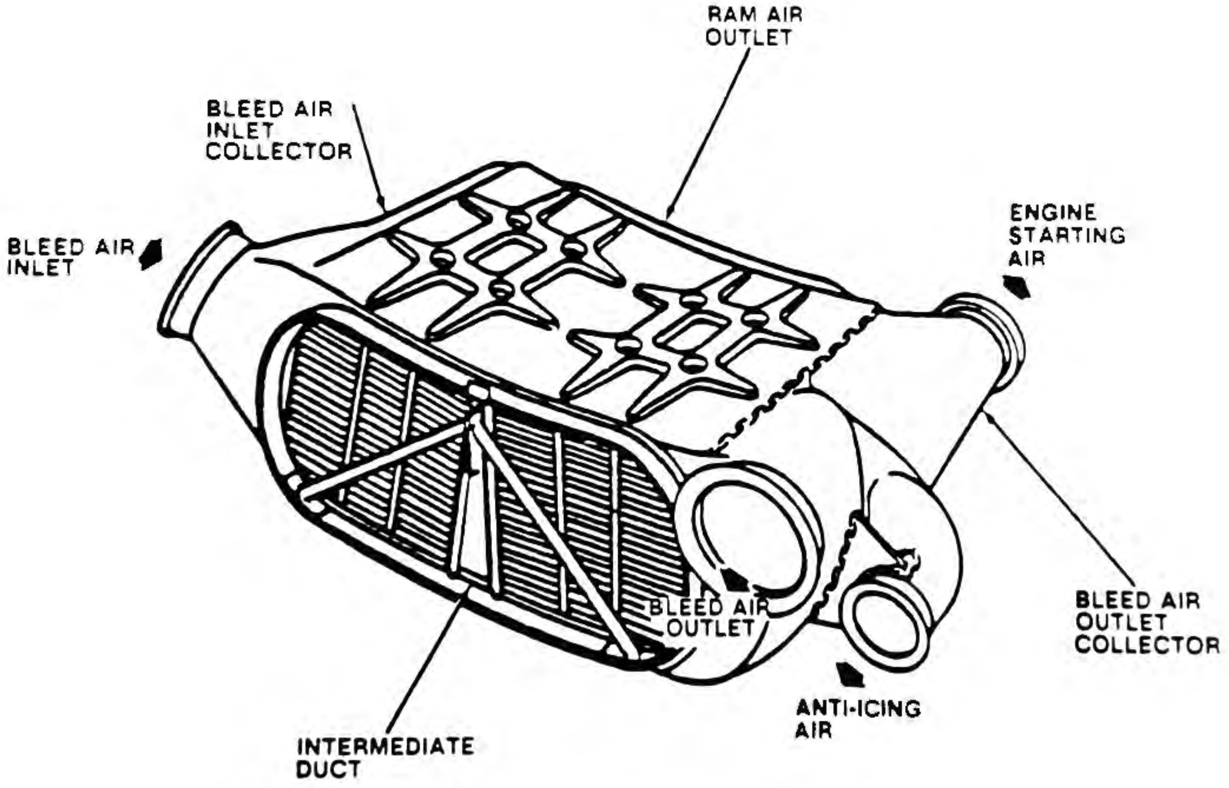
(3) Heat Exchanger (See Figure 36-22)

(a) An air-to-air type engine bleed air heat exchanger is installed on the lower right nose section of each nacelle. High-pressure compressor bleed air is routed through the heat exchanger and cooled before entering the pneumatic manifold.

(b) The heat exchanger is a welded and brazed assembly consisting primarily of two duct header assemblies, two side plates, a tube and header assembly, and two mounting flanges.

(c) The hot bleed air from the high-pressure compressor bleed ports enters the heat exchanger through the bleed air inlet and flows through tubes to the bleed air outlet. Ram air enters through the cooling air inlet, flows around the tubes to cool them, and exists through the cooling air outlet.

(d) The engine anti-icing valve port supplies hot air for anti-icing of the nacelle leading edge engine inlet duct and the oil cooler and engine bleed air heat exchanger scoop. The starter air outlet port supplies air from the heat exchanger downstream header to the engine for starting.



ENGINE BLEED AIR HEAT EXCHANGER SCHEMATIC

FTX80476

Figure 36-22

7. Operation

A. Condition - A/C on the ground, engine at idle. The pneumatic control relay will be deenergized and will direct 115 VAC to the control amplifier. Due to the low temperature of the bleed air passing over the thermister, the amplifier will power the close windings of the actuator and the flap will be closed.

B. Condition - A/C on ground, engine at high power. The control relay will be energized by the closing of the throttle switch and will direct power to the open windings of the actuator and the flap will drive full open.

C. Condition - A/C in flight, engine at any power setting. The control relay will be deenergized by the ground control relay (6) and power will be applied to the amplifier. The thermister will now influence the amplifier to positon the flap actuator as the temperature dictates.

8. Indicating

A. General

(1) The manifold air temperature warning light indicates overtemperature in the pneumatic manifold.

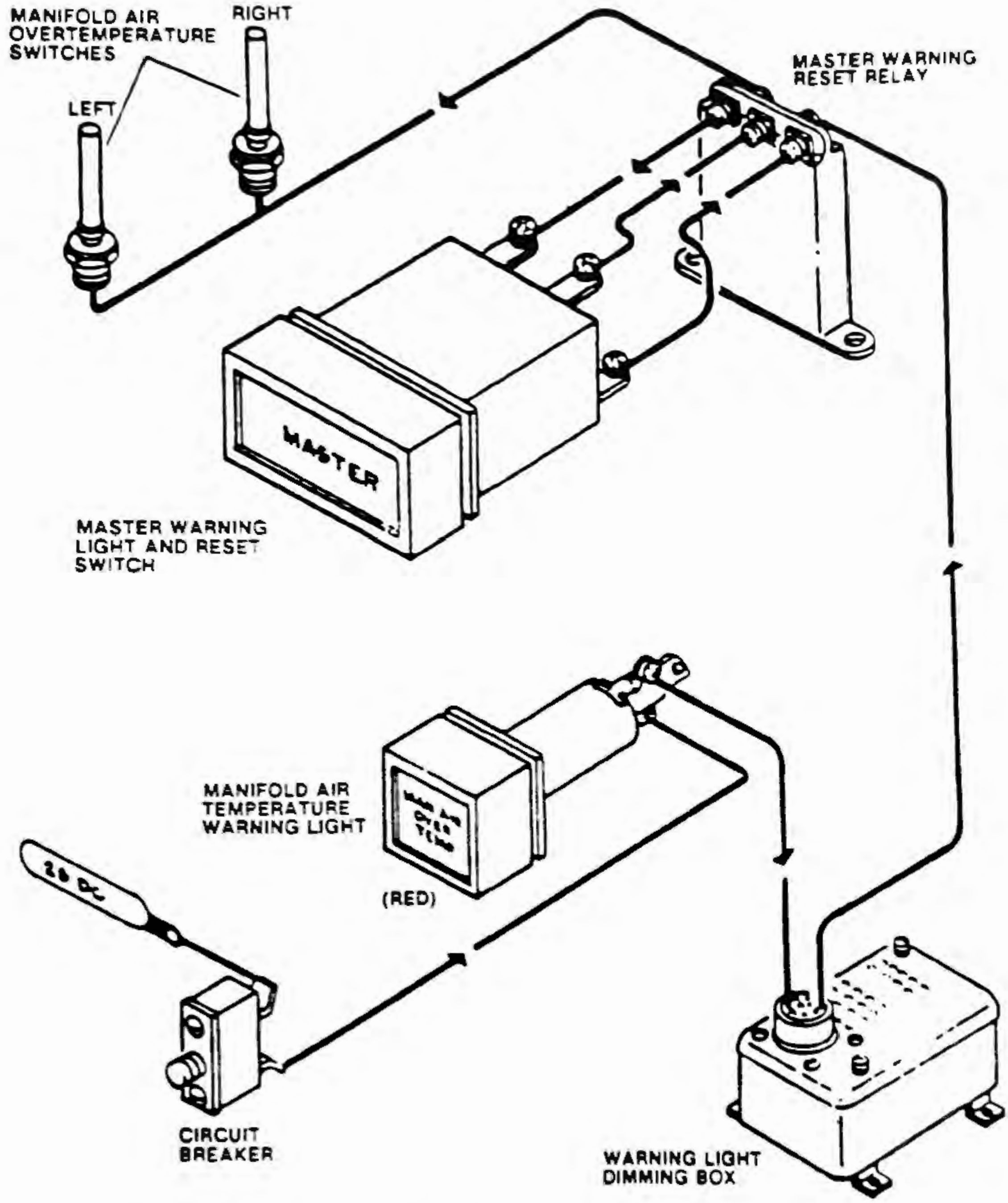
(2) The manifold air temperature indicating system provides a continuous indication of the air temperature in the pneumatic manifold.

(3) The manifold air pressure indicating system provides a continuous indication of the left and right pneumatic manifold pressure.

(4) Other pneumatic indicating systems also include the manifold air pressure and relief valve indicating light, and manifold failure warning lights.

B. Description

(1) Manifold Air Abnormal Temperature Indicating (See Figure 36-23)


MANIFOLD AIR OVERTEMPERATURE SWITCHES
RIGHT
LEFT
MASTER WARNING RESET RELAY
MASTER
MASTER WARNING LIGHT AND RESET SWITCH
MANIFOLD AIR TEMPERATURE WARNING LIGHT
(RED)
28 DC
CIRCUIT BREAKER
WARNING LIGHT DIMMING BOX

MANIFOLD AIR ABNORMAL TEMPERATURE INDICATING

FTX80477

Figure 36-23

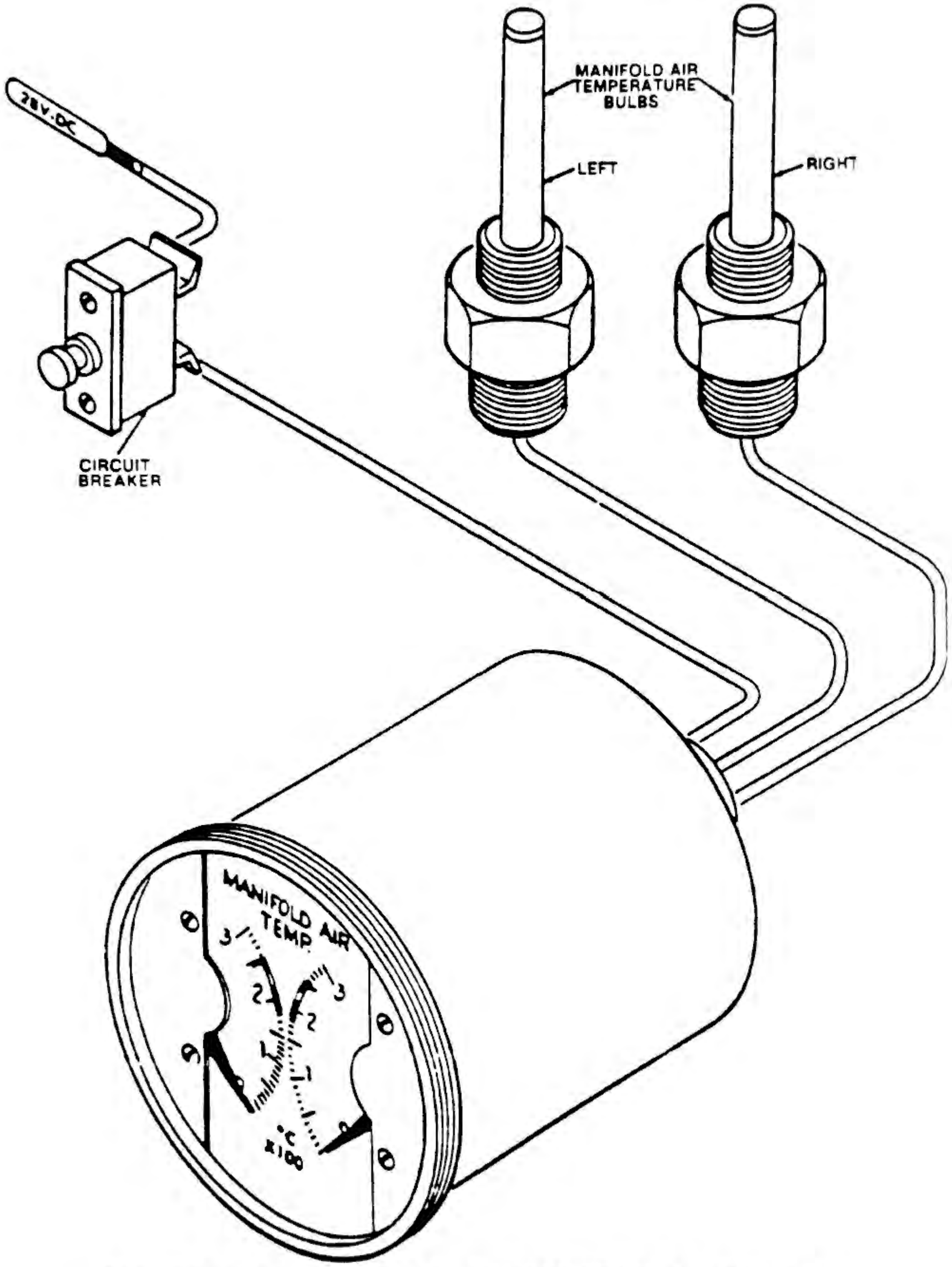
(a) Abnormal temperature indicating consists of a manifold air overtemperature warning light installed on the systems engineer's control panel and two manifold air overtemperature switches which are installed in the left and right pneumatic manifold sections inboard of pylons 2 and 3. The light is placarded MAN AIR OVER TEMP.

(b) When the temperature of the air flowing through the left or right sections of the pneumatic manifold rises to within the range of 234°C to 258°C, as indicated by the manifold air temperature indicator, the corresponding manifold air overtemperature switch closes. The switch completes a ground circuit to the red manifold air overtemperature warning light on the systems engineer's control panel and to the red master warning light on the glareshield. The master warning light reset switch can be used to turn off the master warning light so it can be operated by other warning systems. The manifold air overtemperature light goes off when the temperature drops below the 234°C and 258°C range.

(c) The manifold air overtemperature light might come on briefly in flight if engine power is reduced, as during a landing approach, and then is applied for a go-around. The light comes on because the engine bleed air heat exchanger exhaust flaps close, momentarily, during the time the temperature control system is responding to transient engine power application. The light might also come on momentarily when reverse thrust is applied during landing roll. Reduced ram air flow through the engine bleed air heat exchanger at low ground speeds results in higher-temperature bleed air flowing into the pneumatic manifold.

(d) The overtemperature switch assembly consists of a stainless steel tubular shell, containing the switch contacts and an externally threaded mounting nut. The contacts are mounted on, but insulated from, nickel-iron struts, which are connected to one end of the shell. The closing and opening of the contacts is governed by the expansion and contraction of the shell.

(2) Manifold Air Temperature Indicating (See Figure 36-24)



MANIFOLD AIR ABNORMAL TEMPERATURE INDICATING

FTX80478

Figure 36-24

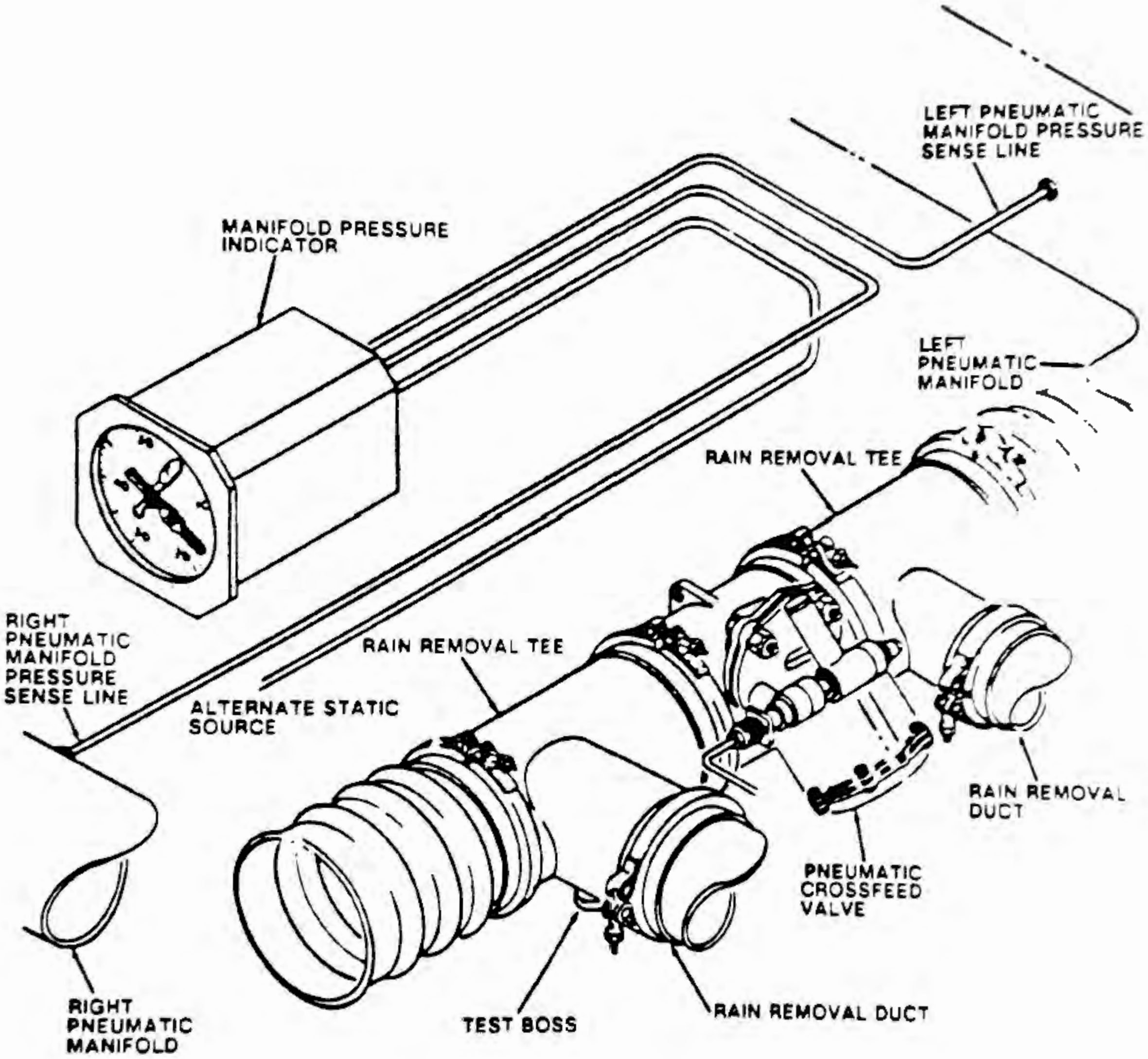
(a) The pneumatic manifold air temperature indicating system provides a continuous indication of the air temperature in the pneumatic manifold. The system consists of a dual ratiometer temperature indicator located on the systems engineer's panel and one temperature-sensing bulb installed in each half of the pneumatic manifold. The temperature-sensing bulbs are connected electrically to the indicator.

(b) The indicator has two scales, one for each section of the pneumatic manifold. The left scale indicates the temperature in the manifold inboard of engine 2. The right scale indicates the temperature inboard of engine 3. The indicator is calibrated in degrees centigrade from 0 to 3 multiplied by 100. Each scale has an undertemperature range indicated by a yellow arc from 182 to 214 degrees, a normal operating range indicated by a green arc from 214 to 242 degrees, and an overtemperature range indicated by a yellow arc from 242 to 258 degrees. A red radial at the 258-degree position indicates the upper limit of the overtemperature range. Cumulative tolerances of the indicator and the manifold air overtemperature warning switch might cause the overtemperature warning light to come on at a temperature as low as 234°C which is within the green arc.

(3) Manifold Air Pressure Indicating (See Figure 36-25)

(a) The manifold air pressure indicating system provides a continuous indication of the left and right pneumatic manifold pressure. The system consists of a standard, integrally lighted, dual manifold air pressure indicator, and a sense line connecting the indicator to the left and right pneumatic manifold pressure sensing ports and to a static reference source.

(b) The manifold pressure indicator is located on the systems engineer's panel. the indicator has two independent pointers on the dial and is calibrated in psig from 0 to 50. It is a mechanical pressure indicator and indicates the pressure in the corresponding half of the pneumatic manifold. The pressure sensing ports are located on each side of the pneumatic manifold crossfeed valve in the air conditioning compartment in the nose.



MANIFOLD AIR PRESSURE INDICATING

FTX80479

Figure 36-25

(4) Manifold air Pressure and Pressure Relief Valve Indicating

(a) The manifold air under pressure indicating light switches are diaphragm-actuated, differential-pressure switches. They are installed approximately 12 inches to the left and right of the fuselage centerline, below the floor on the aft bulkhead of the cabin compressor compartment. The switch housing is a dome shaped enclosure, mounted on a square baseplate. A manifold pressure-sensing line is connected to a port in the bottom of the switch. An electrical receptacle is located at the top of the switch housing.

(b) The port admits manifold air pressure to the lower side of the diaphragm. Vents admit ambient air pressure to the upper side. If pressure in the manifold drops to within the range of 13.5 (±.5) psig, or less, above the ambient air pressure, the diaphragm closes the switch contact. This action completes an electrical circuit to the manifold air pressure indicating light located on the systems engineer's control panel, causing the light to come on. The switch opens the circuit when the manifold air pressure rises to 15.5 psig above the ambient air pressure.

(c) The manifold air pressure indicating light is also electrically connected to the four pneumatic pressure relief valves. When a relief valve opens, the light comes on and remains on until the valve closes.

(5) Manifold Failure Indicating

(a) Manifold failure indicating is provided to indicate a rupture in the left or right pneumatic manifold ducts that are routed through the utility tunnel on each side of the forward cargo compartment and in the air conditioning accessory compartment. Each indicating circuit, one for the left manifold and one for the right manifold, consist of a warning light, amplifier, and sensing elements.

(b) The manifold failure sensing elements are located adjacent to and along the specified length of the manifold. In the event of a duct failure, the hot pneumatic air escaping from the duct is sensed by the manifold failure sensing elements. As temperature increases, the resistance between the center core and the grounded outer jacket of the elements decreases. At a temperature of 255 (±12)

°F (123.9 ±6.5 °C), the resistance should be in the range of 75 to 170 ohms. The corresponding manifold rupture warning amplifier, located in the aft EPC equipment panel, senses this low resistance and applies 28 vdc to the corresponding manifold failure light located on the systems engineer's control panel and the light comes on. A circuit integrity check of each manifold failure indicating circuit may be performed by depressing the corresponding manifold failure light. This action provides the grounding circuit required for the amplifier to apply voltage for the light to come on.

DC-8-61

ENGINE PNEUMATICS

PNEU CONTROL SWITCH POSITION	GROUND THROTTLE BELOW 18°	MODE THROTTLE ABOVE 18°	FLIGHT MODE	PNEU VALVES
OFF	CLOSED	CLOSED	CLOSED	PRESS. REG. AND S/O
	CLOSED	CLOSED	CLOSED	9TH STAGE S/O
LOW	CLOSED	CLOSED	CLOSED	PRESS. REG. AND S/O
	OPEN	OPEN	OPEN	9TH STAGE S/O
HIGH	OPEN	CLOSED	OPEN	PRESS. REG. AND S/O
	CLOSED	OPEN	CLOSED	9TH STAGE S/O

NOTE:

1. 9TH STAGE VALVE IS PNEUMATICALLY OPENED AND ENERGIZED CLOSED.
2. PRESSURE REGULATOR IS ENERGIZED OPEN AND ENERGIZED CLOSED.
3. THE ABOVE CHART CONDITIONS ARE: NORMAL ELECTRICAL POWER ON AIRCRAFT WITH ENGINE OPERATING AND IT IS THE ONLY PNEUMATIC POWER SOURCE.

FTX80480

Figure 36-26

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1. Description

A. The low-pressure pneumatic system distributes and controls pressurized air supplied form either of two locations on each engine or from a ground source through the connector forward of the nosewheel. Both sources of engine bleed air is supplied from the high pressure compressor section of the engine (see Figure 36-1). One source is from the 12th stage section and is referred to throughout this chapter as low-pressure bleed air. The second source is from the 16th stage section and is referred to as high-pressure bleed air. The pneumatic manifold extends from the outboard pylons, spanwise through the wing, and forward in the fuselage to the nose section. In the nose section, the left and right sections of the manifold are joined by a crossfeed valve. The right section is also connected to the ground source connector through the right rain removal duct.

B. Air is bled from the pneumatic manifold to operate the air conditioning and refrigeration components and to provide for ice protection and windshield rain removal. For cowl and engine anti-icing, air for engine starting can also be provided by the pneumatic system.

C. The following pneumatic system controls, indicators, warning lights, and indicating lights are provided for controlling and monitoring the pneumatic system:

(1) Control switches

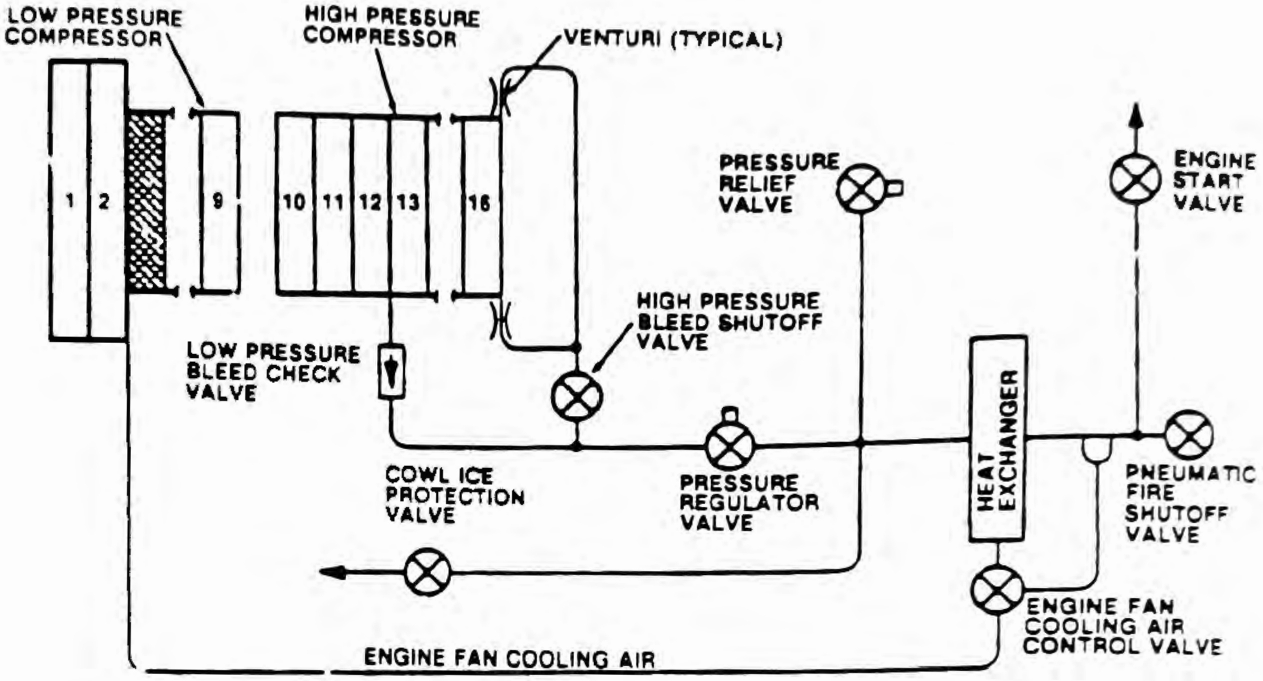
(2) Manifold air temperature indicator

(3) Manifold air overtemperature warning light

(4) Manifold failure indicating lights

(5) Manifold air pressure indicator

(6) Manifold air pressure indicating light



PNEUMATIC SYSTEM MECHANICAL SCHEMATIC

FTX80481

Figure 36-1

D. Blowout doors are used to prevent structural damage due to a pressure buildup in the event of a high-flow leak in the pneumatic ducts. Blowout doors are located in the following areas:

(1) Lower surface of the wing leading edge between the inboard and outboard pylons

(2) In each of the four pylons

(3) In the nose cowl of each engine

(4) In the engine access doors

2. To Operate System

A. Pressurizing Pneumatic System Utilizing Engines

(1) Check that following controls are in positions indicated.

Control	Position
Thrust brake levers	Forward
Fire control handles	Normal
Windshield rain removal levers	Off
Engine anti-icing switches	Off
Scoops anti-icing switch	Off
Airfoil deicing switch	Off
Cabin compressor switches	Off
Refrigerant compressor switches	Off
Pneumatic manifold crossfeed switch	Normal
Pneumatic system shutoff switches	Off

(2) Start engine or engines

(a) One engine (No. 2 or No. 3) for pressurizing manifold and pressure tests requiring limited capacity.

(b) Two engines (No. 2 and No. 3) for stabilizing temperature on each side and for greater capacity for using systems.

(c) All four engines for all systems' checkouts.

(3) Place low-pressure pneumatic shutoff switches, located on systems engineer's panel, in low position.

(4) Slowly advance No. 1 throttle from idle position and check following:

(a) Manifold air pressure light goes off as pressure increases above 15.5 psig, as shown on manifold pressure indicator.

(b) Manifold air pressure increases to and stabilizes at 38 (+ 2) psig.

NOTE: This light also comes on when an overpressure condition exists and a relief valve opens. When the airplane is on the ground with a throttle advanced less than approximately 18 degrees (1 9/16 inch) from the idle stop, the corresponding high pressure bleed valve is open and air is supplied from the high-pressure bleed ports. When the throttle is advanced past approximately 18 degrees form the idle stop, the throttle limit switch is actuated which closes the high pressure bleed valve and air is supplied from the low-pressure bleed ports. The control circuit changes the bleed source from low to high-pressure source when the nose gear oleo switch is actuated by touchdown of the nosegear.

(5) Retard throttle and repeat Steps (4 and 5) for engines 2, 3, and 4.

B. Pressurizing Pneumatic System Utilizing Ground Pneumatic Source

(1) Check that following controls are in positions indicated:

Control	Position
Starter and ignition arming switch	Off
Fire control handles	Normal
Windshield rain removal levers	Off
Engine anti-icing switches	Off
Scoops anti-icing switch	Off
Airfoil deicing switch	Off
Cabin compressors switches	Off

Refrigerant compressor switches	Off
Pneumatic manifold crossfeed switch	Normal
Pneumatic system shutoff switches	Off

(2) Connect ground pneumatic source to fuselage ground pneumatic co nector.

NOTE: **Ground pneumatic source must supply air with a flo of 20 ppm at a pressure of 38 (±2) psig. The air supplied must have a cleanness equivalent to that obtai by using a 10-micron filter and must have a minimu amount of entrained oil or water. If heated air is use the temperature must not exceed 237.8°C (460°F).**

(3) Check that ground source pneumatic pressure regulator is set to provide pressure of 38 (±2) psig.

NOTE: **The manifold sections will not regulate ground sour air; however, the pressure relief valves in each of th nacelles will relieve pressures that exceed approximately 45.5 to 47 psig.**

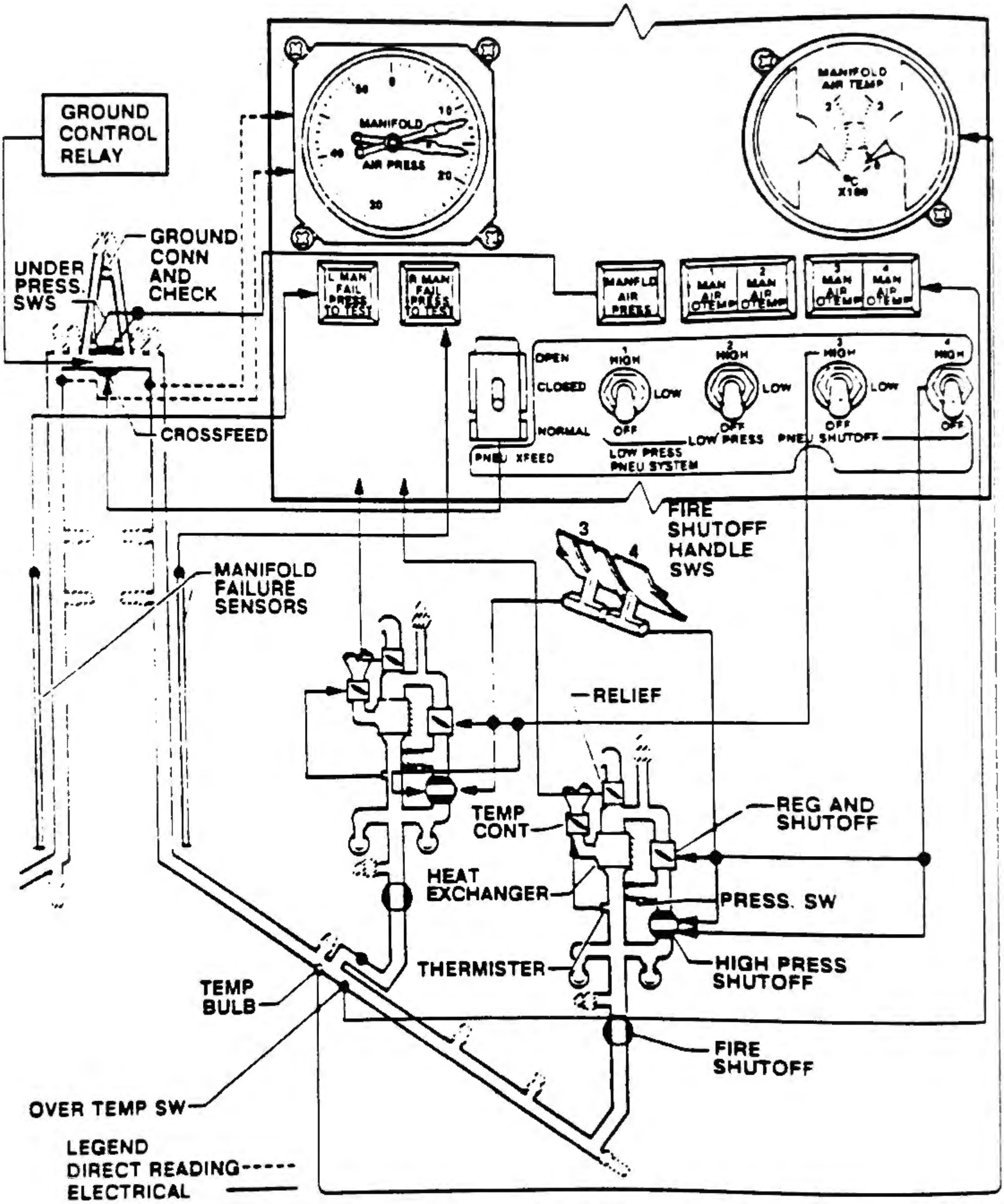
3. Distribution

A. General (See Figure 36-2)

(1) The high-pressure and low-pressure bleed air for the distribution system is supplied to the pylon duct through a system of ducts an valves at a regulated pressure and temperature.

(2) An external source of air can be connected to supply the pneumat system when the airplane is on the ground and the engines are no operating.

B. Description (See Figure 36-3)

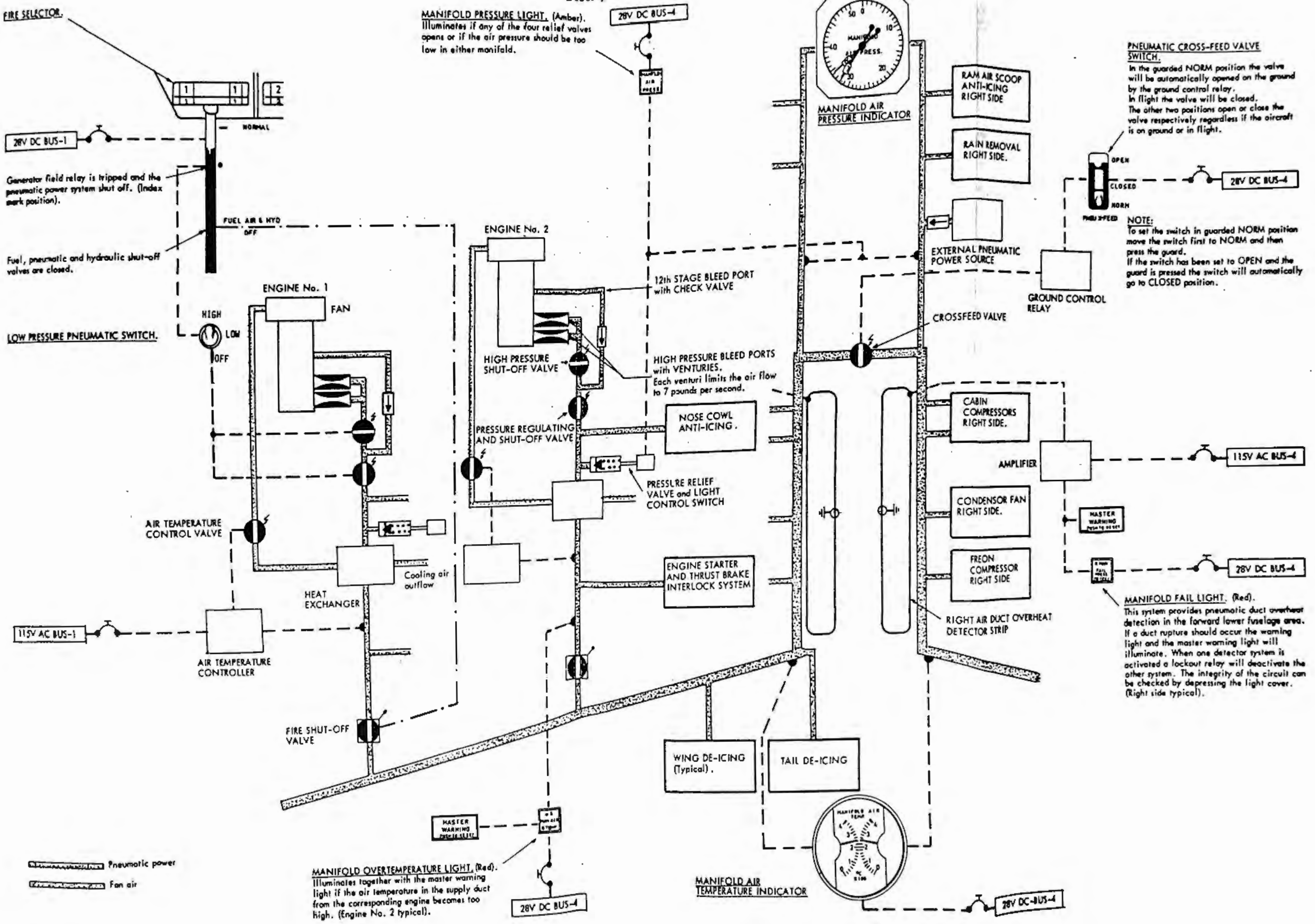


FTX80640

DC8-62 PNEUMATIC SYSTEM SCHEM

Figure 36-2

PNEUMATIC
Description


28V DC BUS-4
MANIFOLD AIR PRESSURE INDICATOR
MANIFOLD AIR PRESS.
RAM AIR SCOOP ANTI-ICING RIGHT SIDE
RAIN REMOVAL RIGHT SIDE.
EXTERNAL PNEUMATIC POWER SOURCE
GROUND CONTROL RELAY
OPEN
CLOSED
NORM
PNEU X-FEED
28V DC BUS-4
NORMAL
28V DC BUS-1
FUEL AIR & HYD OFF
ENGINE No. 2
ENGINE No. 1
FAN
HIGH
LOW
OFF
12th STAGE BLEED PORT with CHECK VALVE
CROSSFEED VALVE
HIGH PRESSURE SHUT-OFF VALVE
HIGH PRESSURE BLEED PORTS with VENTURIES. Each venturi limits the air flow to 7 pounds per second.
PRESSURE REGULATING AND SHUT-OFF VALVE
NOSE COWL ANTI-ICING.
CABIN COMPRESSORS RIGHT SIDE.
AMPLIFIER
115V AC BUS-4
PRESSURE RELIEF VALVE and LIGHT CONTROL SWITCH
CONDENSOR FAN RIGHT SIDE.
MASTER WARNING
AIR TEMPERATURE CONTROL VALVE
FREON COMPRESSOR RIGHT SIDE
28V DC BUS-4
ENGINE STARTER AND THRUST BRAKE INTERLOCK SYSTEM
Cooling air outflow
HEAT EXCHANGER
RIGHT AIR DUCT OVERHEAT DETECTOR STRIP
115V AC BUS-1
AIR TEMPERATURE CONTROLLER
FIRE SHUT-OFF VALVE
WING DE-ICING (Typical).
TAIL DE-ICING
MASTER WARNING
MANIFOLD AIR TEMP
28V DC BUS-4
MANIFOLD AIR TEMPERATURE INDICATOR
28V DC-BUS-4
Pneumatic power
Fan air

FIRE SELECTOR.

Generator field relay is tripped and the pneumatic power system shut off. (Index mark position).

Fuel, pneumatic and hydraulic shut-off valves are closed.

LOW PRESSURE PNEUMATIC SWITCH.

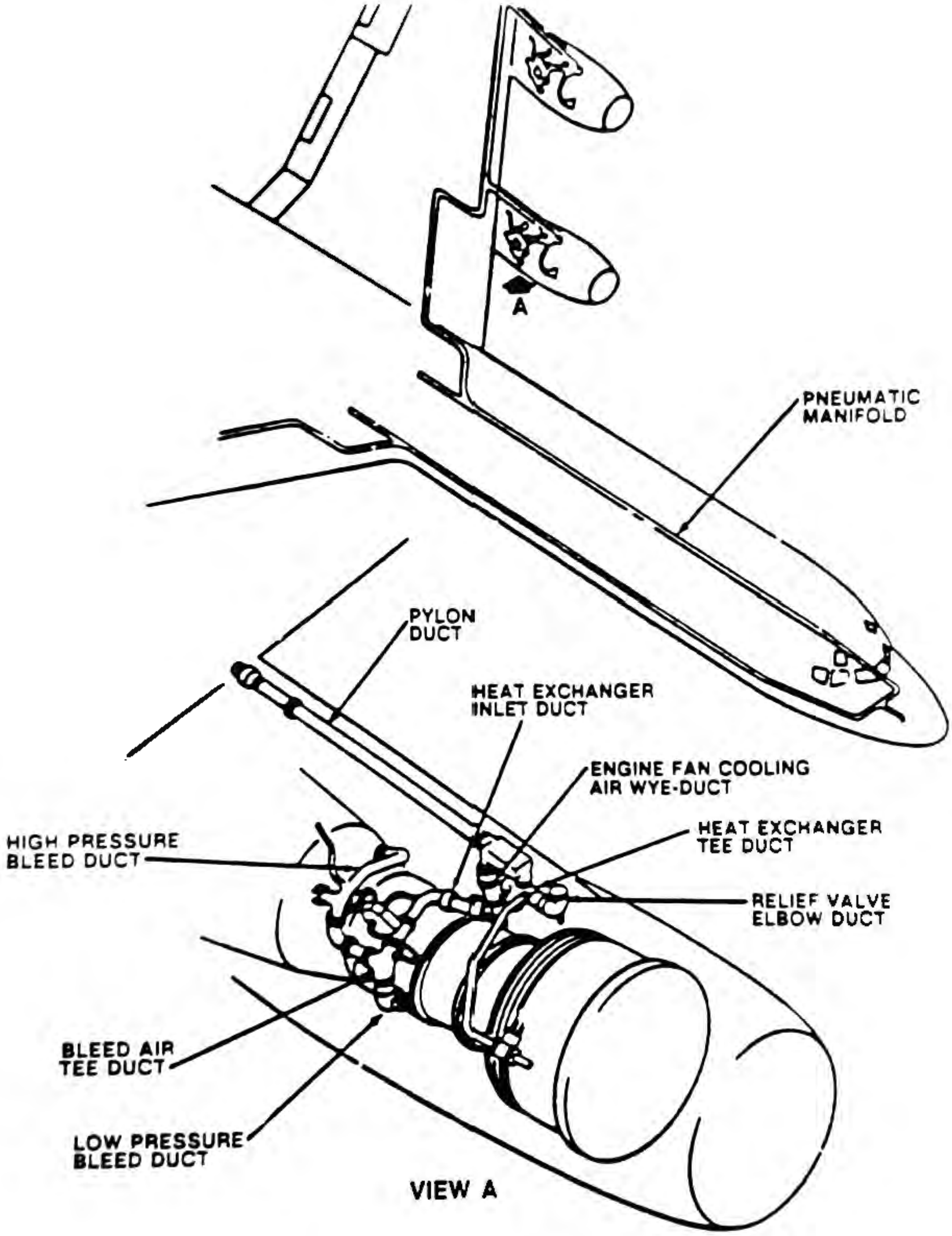
MANIFOLD PRESSURE LIGHT. (Amber).
Illuminates if any of the four relief valves opens or if the air pressure should be too low in either manifold.

PNEUMATIC CROSS-FEED VALVE SWITCH.
In the guarded NORM position the valve will be automatically opened on the ground by the ground control relay.
In flight the valve will be closed.
The other two positions open or close the valve respectively regardless if the aircraft is on ground or in flight.

NOTE:
To set the switch in guarded NORM position move the switch first to NORM and then press the guard.
If the switch has been set to OPEN and the guard is pressed the switch will automatically go to CLOSED position.

MANIFOLD FAIL LIGHT. (Red).
This system provides pneumatic duct overheat detection in the forward lower fuselage area. If a duct rupture should occur the warning light and the master warning light will illuminate. When one detector system is activated a lockout relay will deactivate the other system. The integrity of the circuit can be checked by depressing the light cover. (Right side typical).

MANIFOLD OVERTEMPERATURE LIGHT. (Red).
Illuminates together with the master warning light if the air temperature in the supply duct from the corresponding engine becomes too high. (Engine No. 2 typical).



PNEUMATIC SYSTEM DUCTING

FTX80483

Figure 36-3

(1) High-pressure bleed air is ducted from two bleed ports in the engine diffuser case through a shutoff valve, pressure regulator valve, past a pressure relief valve, and into the heat exchanger. From the heat exchanger, the air is ducted through the pylon duct, the pneumatic fire shutoff valve, and into the pneumatic manifold.

(2) Low-pressure bleed air is ducted from a bleed port in the compressor case through a check valve, bleed air T-duct and into the high pressure bleed duct upstream of the pressure regulator valve.

(3) The pneumatic manifold starts at the outboard pylon in each wing and extends to the fuselage and into the fuselage nose section where the left and right sections are connected by a crossfeed valve. Pressurized air for the using systems is bled from the manifold.

C. Operation

The pneumatic shutoff switches are provided to select either bleed air source of the corresponding engine. During ground operations when the switch is in the low position, the source is automatically transferred to the high-pressure bleed when the engine throttle is in a position between idle and 1 9/16 inches from the idle stop. The low position is used for ground operations, takeoff, and normal cruise. The high position is used if the demands made upon the system are so great that an undertemperature or underpressure condition exists.

4. Ducting

A. General

(1) Engine bleed air is distributed throughout the airplane by a system of ducts. All ducts downstream of the heat exchanger are insulated. The insulation generally consists of layers of baked fiberglass covered with neoprene. The ends of the covering, which are in contact with the duct, are made of a silicone-impregnated fiberglass cloth that can withstand the high duct temperatures.

(2) The system of ducts from the pressure regulator valve to the heat exchanger inlet is referred to as a tension system because the ducts are subjected to tension loads when the pneumatic system is in operation. The ducts, between the heat exchanger and the pressure regulator valve, are connected by a metal bellows and knuckle-joint

(universal joint) combination and supported by linkages form the engine casing. This method of installation permits movement of the ducts to compensate for expansion and contraction of the ducts and engine.

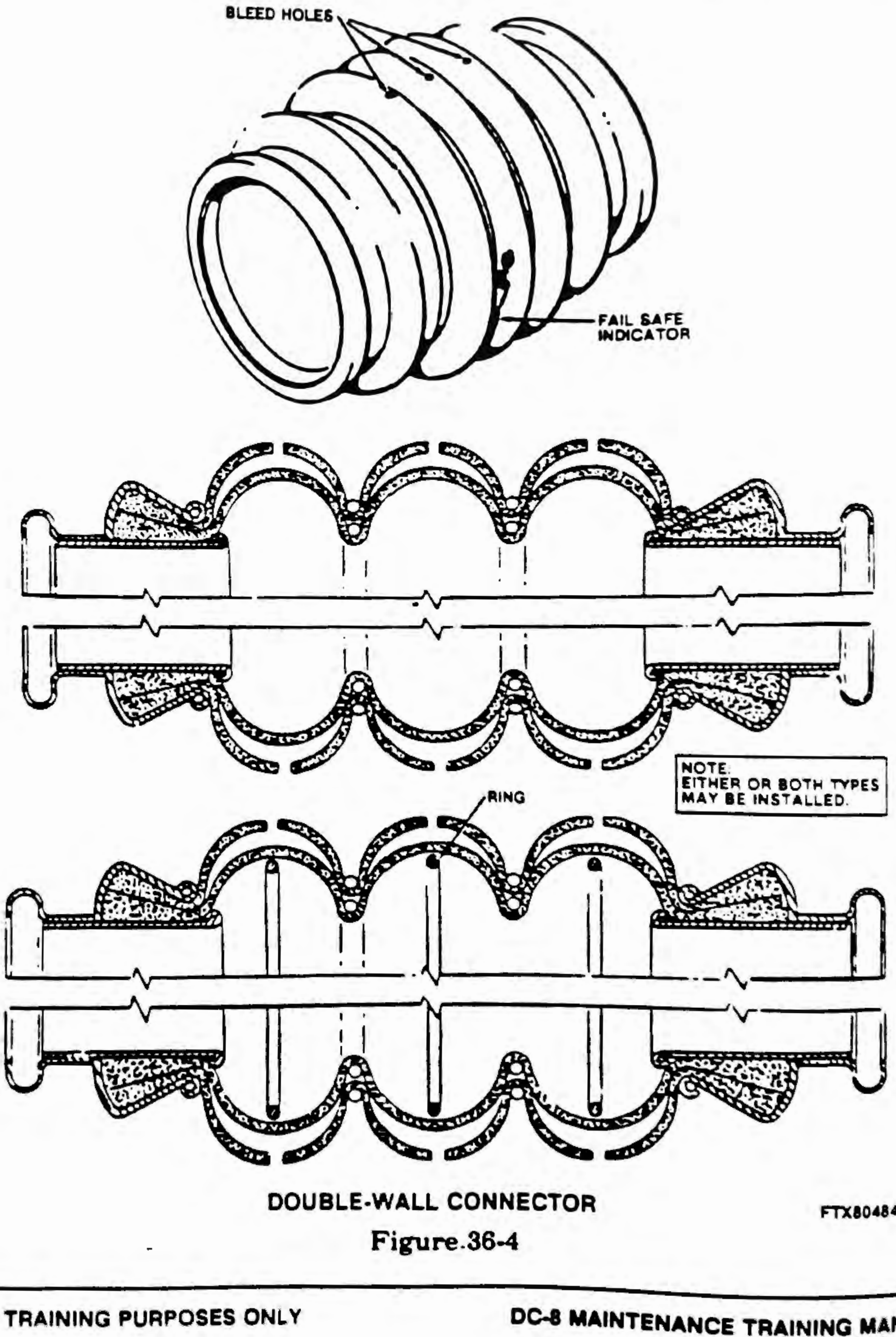
(3) The system of ducts forming the pylon ducts and pneumatic manifold is referred to as a compression system because the ducts are subjected to compression loads when the pneumatics systems is in operation One end of each manifold assembly is held rigid by a fixed support. A slip-type support at the other end allows the duct assemblies to expand and contract with changes in temperature. The slip supports also allow the ducts to slip freely during airplane structural deflections. The duct assemblies are joined by flexible connectors made form a silicone-impregnated fiberglass material.

B. Component Description

(1) Duct Connectors (See Figure 36-4)

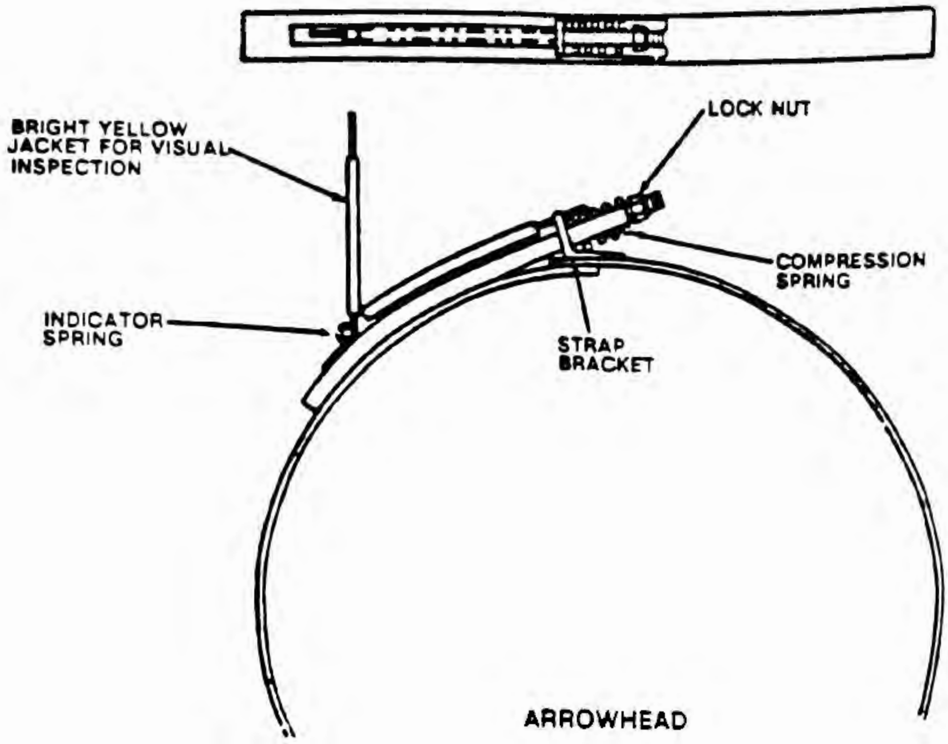
(a) The duct connectors are double wall connectors. The connectors permit expansion and contraction of the pneumatic ducts with changes in temperature and allow for structural deflection.

(b) The duct connectors are installed in the pylons, in the wings, on both sides of the fuselage, and in the fuselage nose section. The connectors are attached to the manifold duct assemblies with V-band type couplings. The bellow-shaped walls of the connectors are made from a silicone-impregnated fiberglass material and have a coupling flange attached to each end. A spring-loaded, fail-safe indicator is attached to a metal band circling the connector (see Figure 36-5). If the inner wall of the connector should leak excessively, expansion of the outer wall causes the metal strip to expand and thereby allow a spring-loaded flag (indicator) to snap out of the strap bracket. Normal inner wall leakage is less than 0.003 pounds of air per minute per inch diameter. The outer wall is vented to compensate for this normal inner wall leakage.

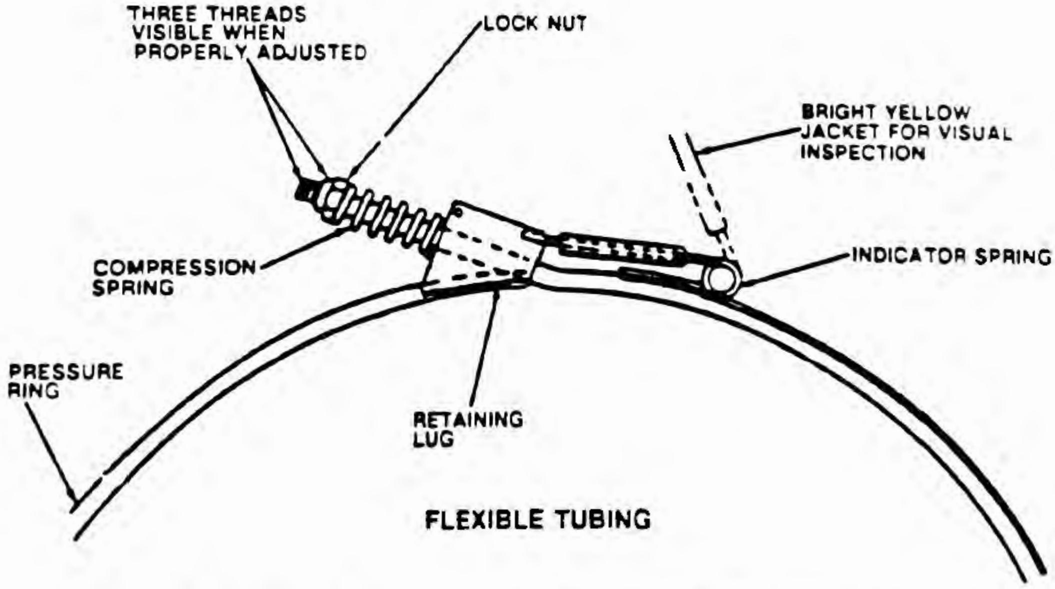


DOUBLE-WALL CONNECTOR

Figure.36-4



ARROWHEAD


THREE THREADS VISIBLE WHEN PROPERLY ADJUSTED
LOCK NUT
BRIGHT YELLOW JACKET FOR VISUAL INSPECTION
INDICATOR SPRING
COMPRESSION SPRING
PRESSURE RING
RETAINING LUG

FLEXIBLE TUBING

FAIL-SAFE INDICATOR ADJUSTMENT DIAGRAM

FTX80485

Figure 36-5

(2) High-Pressure Bleed Duct (See Figure 36-6)

A high-pressure bleed air duct is installed on the upper surface of each engine. Access to the duct is gained by removing the engine fan air ducts. High-pressure bleed air is directed by the duct from two bleed ports in the engine diffuser case, through an elbow duct, to a bleed air shutoff valve. The duct is connected to the engine bleed ports by attaching bolts in each flange; and to the elbow duct and shutoff valve by V-clamps.

(3) Low-Pressure Bleed Duct

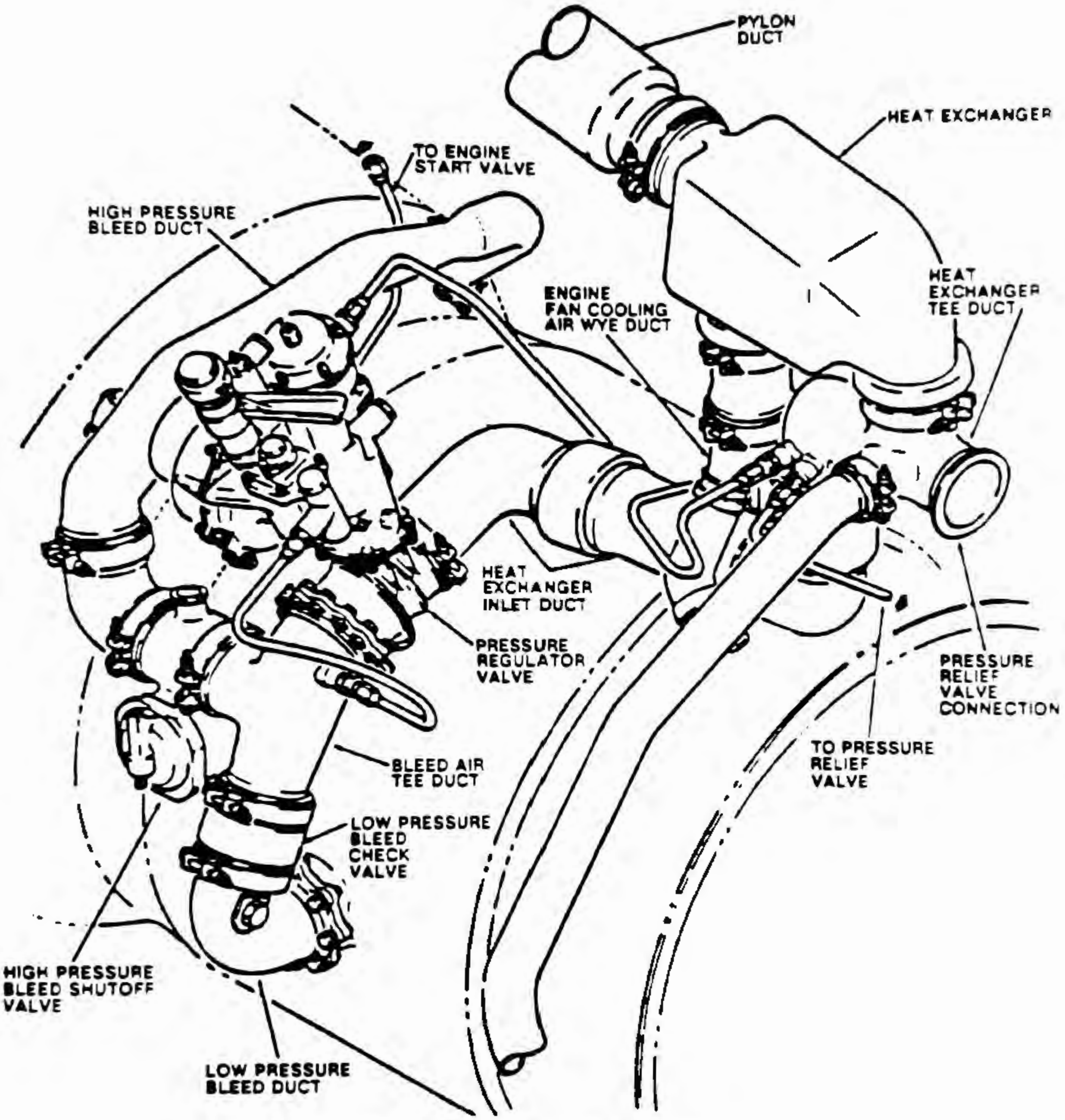
A low-pressure bleed duct is installed approximately at the 3 o'clock position on the compressor intermediate case of each engine. It is a closed angle elbow duct, and supplies low-pressure air from the bleed port to a check valve. The duct is attached to the bleed port by bolts. The outlet port of the duct is connected to the check valve by a V-clamp.

(4) Bleed Air Tee Duct

A bleed air tee duct is connected to the high-pressure bleed air shutoff valve by a V-clamp, and to the low-pressure bleed air check valve by a V-clamp. The outlet port of the duct is connected to the pressure regulator valve with bolts.

(5) Heat Exchanger Inlet Duct

The heat exchanger inlet duct is installed between the pressure regulator valve and the heat exchanger tee duct. There are four segments connected together by 3 flexible metal connectors: a right angle elbow duct connected to the regulator valve by a V-clamp; a straight duct; and another right angle elbow duct and a short straight duct which is connected to the heat exchanger tee duct.



NACELLE BLEED AIR DUCTS

FTX80486

Figure.36-6

(6) Heat Exchanger Tee Duct

The heat exchanger tee duct is located between the heat exchanger inlet duct and the heat exchanger. The duct is connected to the heat exchanger inlet duct with a flexible metal connector. It has an outlet port forward which is connected to the pressure relief valve with a V-clamp; and an outlet port on the right side connected to the nose cowl ice-protection duct with a V-clamp. The large outlet port on top of the duct connects with the heat exchanger inlet with a V-clamp.

(7) Pylon Ducts (See Figure 36-7)

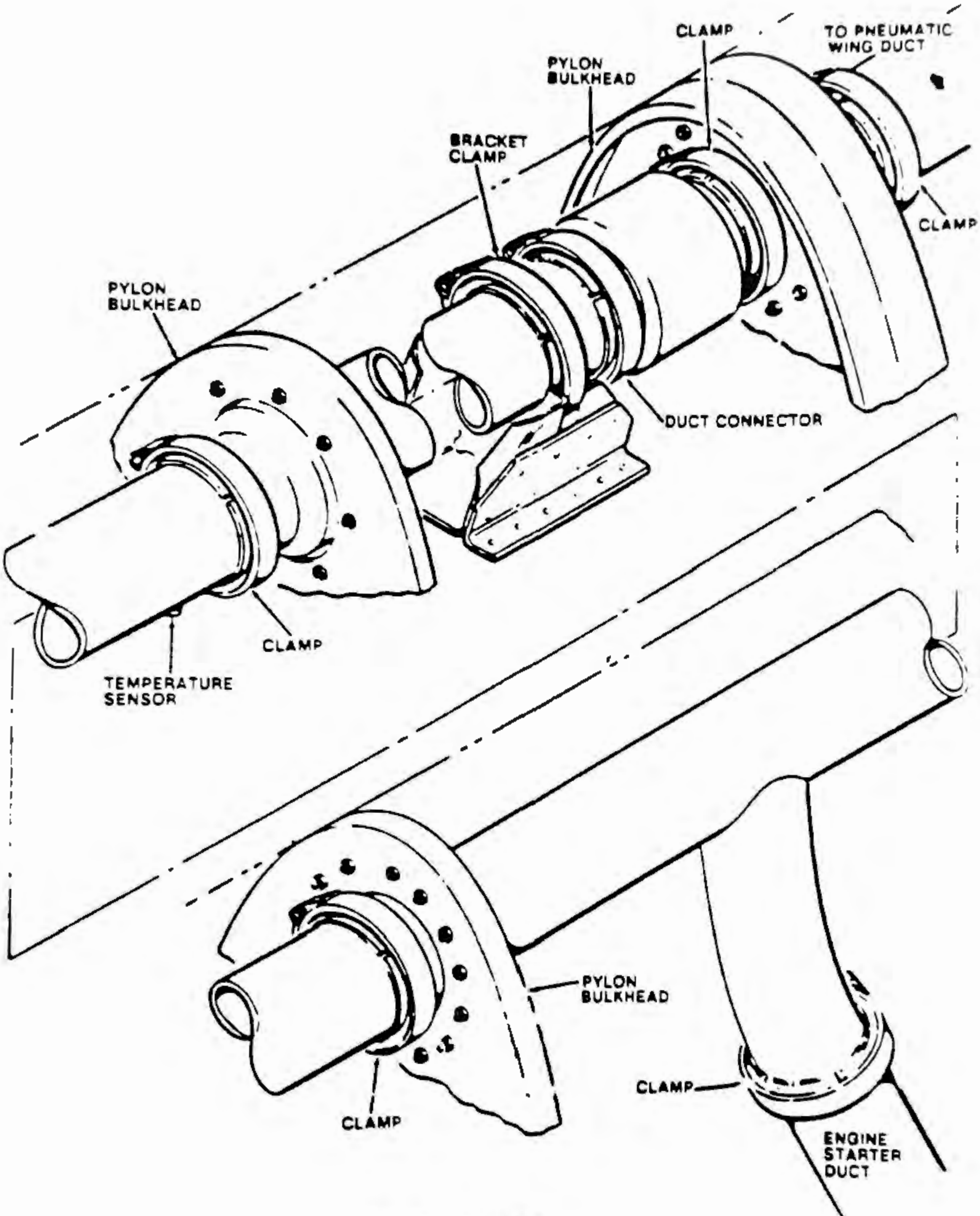
The pylon ducts are located between the heat exchanger and the fire shutoff valve in the wing leading edge. There are 4 segments connected together by 4 V-clamps and 1 flexible duct connector. They are connected to the outlet port of the heat exchanger by a V-clamp; and to the inlet port of the fire shutoff valve with a V-clamp. Just downstream of the heat exchanger outlet port there is a bleed port leading directly into the engine starter duct.

(8) Pneumatic Manifold

The pneumatic manifold extends inboard from the pylons to the fuselage nose section. The portion of the pneumatic manifold from the outboard pylon to the inboard pylon is an integral part of the leading edge and is removed with the wing leading edge. The manifold extends forward along each side of the fuselage, below the floor, in the pressurized area. From the pressurized area the left and right sections of the manifold extend forward and are joined in the fuselage nose section by the pneumatic crossfeed valve.

(9) Ground Source Connector (See Figure 36-8)

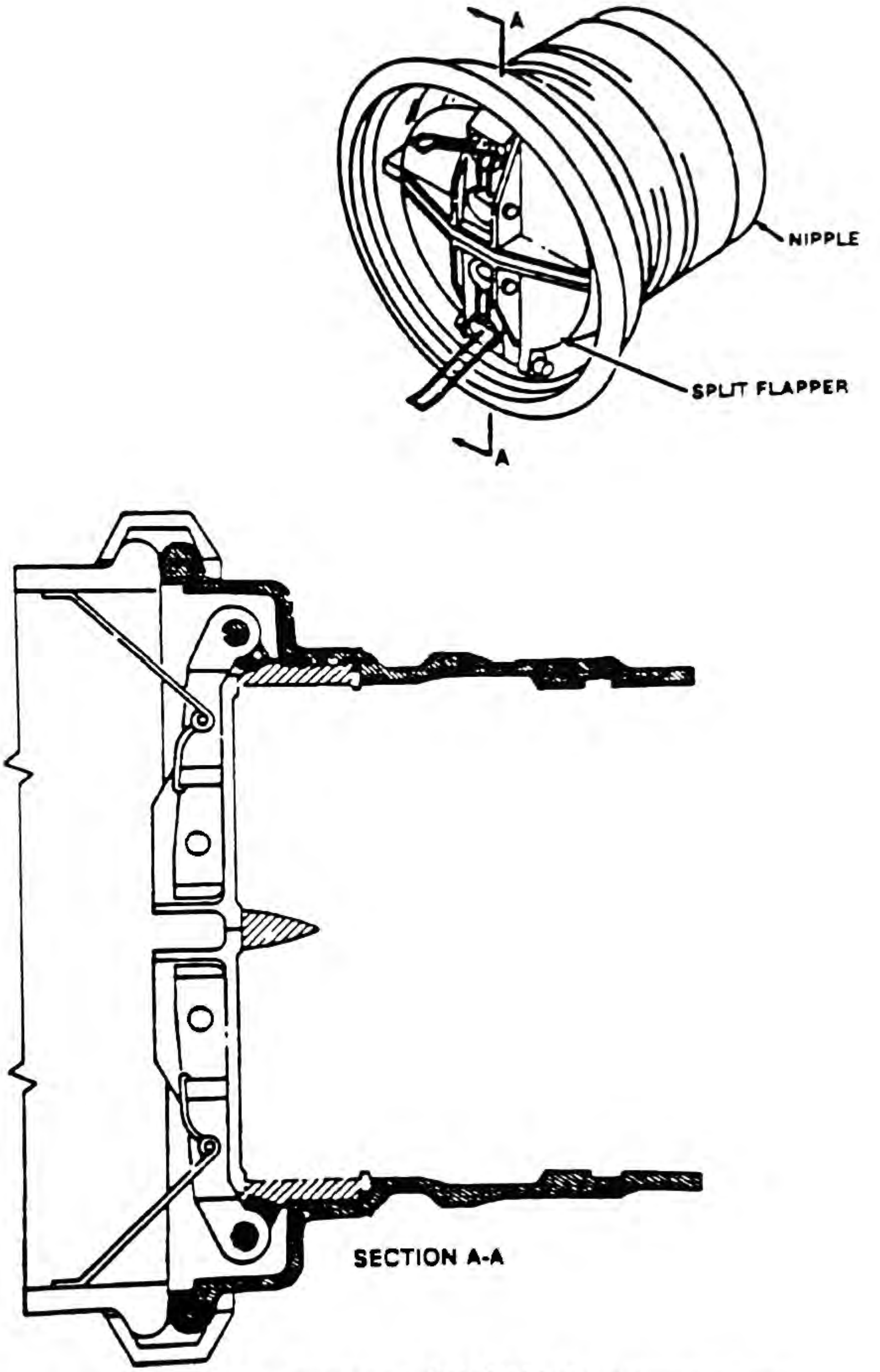
(a) The ground source connector is a nipple-type connector, used to attach a pneumatic ground source to the pneumatic manifold. It also acts as a check valve to prevent air in the pneumatic manifold from discharging overboard. The ground source connector is installed in the rain removal duct, which connects to the pneumatic manifold. The connector is located on the lower fuselage centerline aft of the radome.



PYLON DUCTS

FTX80487

Figure 36-7



FUSELAGE NOSE GROUND PNEUMATIC CONNECTOR

FTX80488

Figure 36-8

(b) When a ground external source of air pressure is connected to the ground pneumatic connector, the valve opens. This allows air to flow into the pneumatic manifold. The check valve is held closed when the pneumatic system is pressurized with engine bleed air.

5. Pressure Regulation and Control

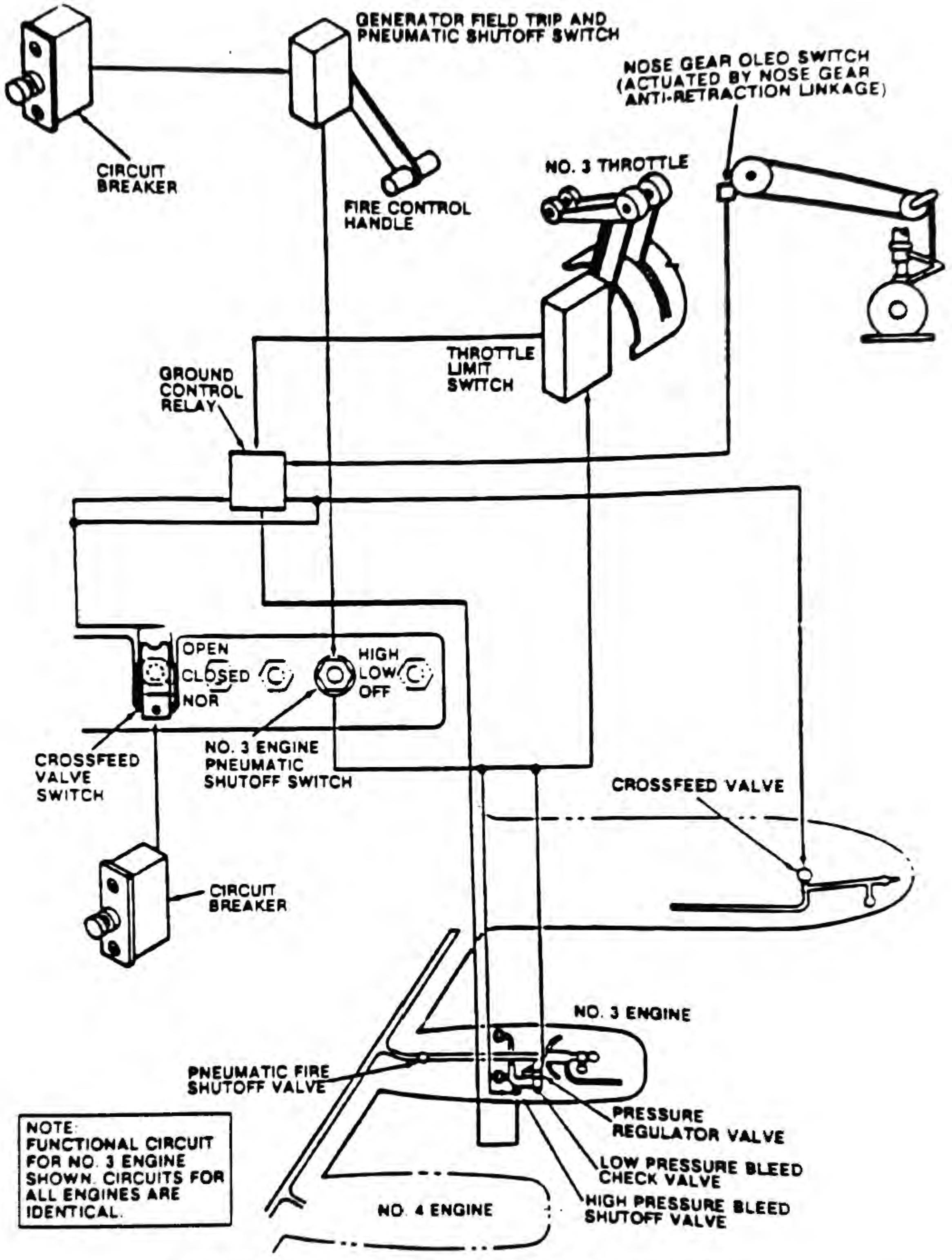
A. General

The pressure regulation and control of the pneumatic system is obtained by the use of components that permit selection of the pressurized air source that protect form overpressure, that regulate the pressure, and that shutoff the system. A crossfeed valve is provided to connect or isolate the left and right sections of the system. The control of ground source air is limited to overpressure control and distribution.

B. Description

(1) Low-Pressure Pneumatic Shutoff Switches (See Figures 36-9 and 36-10)

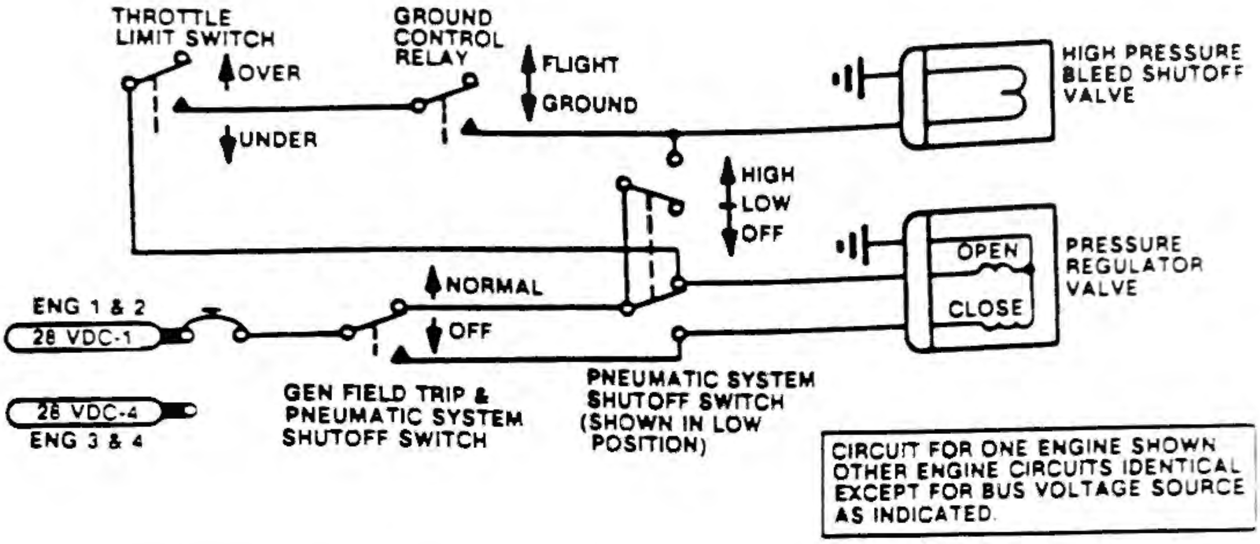
Shutoff switches, one for each engine, are located on the systems engineer's control panel. Three switch positions provide for selection of engine bleed air to the pneumatic system. Off position shuts off all engine bleed air to the system. High position supplies electrical power directly to the solenoid of the high pressure bleed shutoff valve, overriding the ground automatic operation of the system. When the solenoid is energized, the shutoff valve opens to allow high pressure bleed air to enter the pneumatic system. The low position provides automatic operation of the high pressure bleed shutoff valve, when the airplane is on the ground, through a throttle limit switch and engine ground control relay. The automatic feature ensures that high pressure bleed air is supplied to the pneumatic system when the airplane is on the ground and an engine is operating at a low rpm (throttle lever advanced less than approximately 1 9/16 inches from the idle stop). The circuit to the shutoff valve solenoid is interrupted when the throttle is advanced pass the 1 9/16 inches from idle or the ground control relay is deenergized and the high pressure bleed shutoff valve closes.


GENERATOR FIELD TRIP AND PNEUMATIC SHUTOFF SWITCH
NOSE GEAR OLEO SWITCH (ACTUATED BY NOSE GEAR ANTI-RETRACTION LINKAGE)
CIRCUIT BREAKER
FIRE CONTROL HANDLE
NO. 3 THROTTLE
THROTTLE LIMIT SWITCH
GROUND CONTROL RELAY
OPEN
CLOSED
NOR
HIGH
LOW
OFF
CROSSFEED VALVE SWITCH
NO. 3 ENGINE PNEUMATIC SHUTOFF SWITCH
CROSSFEED VALVE
CIRCUIT BREAKER
NO. 3 ENGINE
PNEUMATIC FIRE SHUTOFF VALVE
PRESSURE REGULATOR VALVE
LOW PRESSURE BLEED CHECK VALVE
HIGH PRESSURE BLEED SHUTOFF VALVE
NO. 4 ENGINE
NOTE: FUNCTIONAL CIRCUIT FOR NO. 3 ENGINE SHOWN. CIRCUITS FOR ALL ENGINES ARE IDENTICAL.

PNEUMATIC CONTROL FUNCTIONAL DIAGRAM

FTX80489

Figure 36-9


THROTTLE LIMIT SWITCH
OVER
UNDER
GROUND CONTROL RELAY
FLIGHT
GROUND
HIGH PRESSURE BLEED SHUTOFF VALVE
HIGH
LOW
OFF
OPEN
CLOSE
PRESSURE REGULATOR VALVE
ENG 1 & 2
28 VDC-1
NORMAL
OFF
28 VDC-4
ENG 3 & 4
GEN FIELD TRIP & PNEUMATIC SYSTEM SHUTOFF SWITCH
PNEUMATIC SYSTEM SHUTOFF SWITCH (SHOWN IN LOW POSITION)
CIRCUIT FOR ONE ENGINE SHOWN OTHER ENGINE CIRCUITS IDENTICAL EXCEPT FOR BUS VOLTAGE SOURCE AS INDICATED.

PRESSURE REGULATION AND CONTROL ELECTRICAL SCHEMATIC

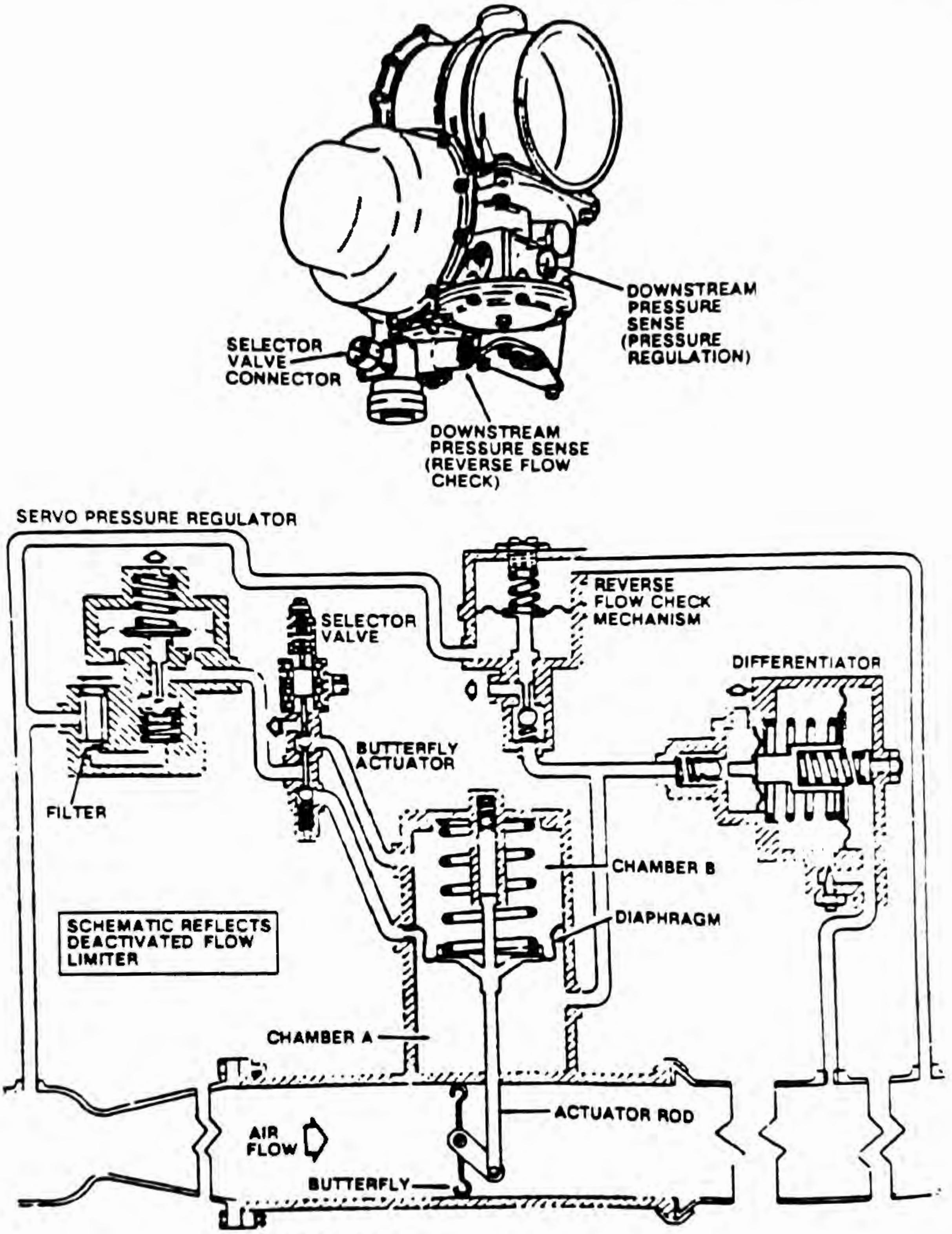
FTX80490

Figure 36-10

(2) Pressure Regulator Valve (See Figure 36-11)

(a) A pneumatic pressure regulator valve is located at approximately the 2 o'clock position on the compressor intermediate case of each engine and connects the bleed air tee duct and the heat exchanger inlet duct of each engine. It is an electrically controlled, pneumatically actuated, butterfly-type valve. An indicator on the exterior of the valve shows the relative position of the butterfly valve. The valve regulates the pressure of the air bled from the high-pressure compressor to 38 (±2) psig. The regulated pressure of 38 psig is reached only when the engine power setting is high enough to give 38 psig, or more, upstream of the valve.

(b) The body of the valve consists of three housings, bolted together, containing the various subassemblies of the valve. The valve has an electrical connector for the solenoid-operated, double-ball selector valve. There are three ports in the valve for connecting 5/16-inch sense lines. One port admits downstream pressure for pressure regulation, one admits downstream pressure for reverse flow check, and one admits upstream pressure for servo pressure to actuate the butterfly valve.


DOWNSTREAM PRESSURE SENSE (PRESSURE REGULATION)
SELECTOR VALVE CONNECTOR
DOWNSTREAM PRESSURE SENSE (REVERSE FLOW CHECK)
SERVO PRESSURE REGULATOR
SELECTOR VALVE
REVERSE FLOW CHECK MECHANISM
DIFFERENTIATOR
BUTTERFLY ACTUATOR
FILTER
CHAMBER B
DIAPHRAGM
SCHEMATIC REFLECTS DEACTIVATED FLOW LIMITER
CHAMBER A
ACTUATOR ROD
AIR FLOW
BUTTERFLY
FTX80491

PRESSURE REGULATOR VALVE

Figure 36-11

(c) The subassemblies contained in the pressure regulator valve and the basic function of each are listed below:

1 A butterfly valve actuator assembly, consisting of a spring-loaded diaphragm, an actuating rod, a butterfly valve, and a cam assembly. This assembly adjusts the butterfly valve to regulate the quantity of air passing through the valve.

2 A servo pressure regulator assembly, consisting of a 40-micron filter and a diaphragm actuated, spring-loaded poppet valve. The pressure regulator controls the air pressure in the butterfly valve actuator assembly.

3 A solenoid-operated, on-off selector valve assembly, consisting of a latching solenoid and a double-ball selector valve. This valve directs air pressure to the butterfly actuator assembly to either open or close the butterfly valve.

4 A reverse-flow check valve assembly, consisting of a spring-loaded diaphragm and a spring-loaded poppet valve. This valve assembly prevents reverse airflow through the butterfly valve.

5 A differentiator assembly (a rate-type pressure control), consisting of an adjustable orifice, two spring-loaded diaphragms, and a spring-loaded ball valve. The differentiator assembly controls the butterfly valve actuator assembly to regulate air pressure in the pneumatic system to 38 (±2) psig.

(d) The butterfly valve is spring-loaded to the closed position, when the engines are not operating. With an engine operating, the close coil in the solenoid of the selector valve is energized when the corresponding engine fire control handle is moved to the hydraulic, air and fuel off position; regardless of the pneumatic system shutoff switch position. The solenoid holds the double-ball selector valve in off position. Air is then routed form the upstream sense port, through the 40-micron filter and to the selector valve. The selector valve directs the air to the top of the diaphragm in the actuator assembly (chamber B). At the same time, air from the bottom of the diaphragm in the actuator (chamber A) is vented to atmosphere. Since the pressure in chamber B is greater than the pressure in chamber A, the butterfly valve remains in the closed position.

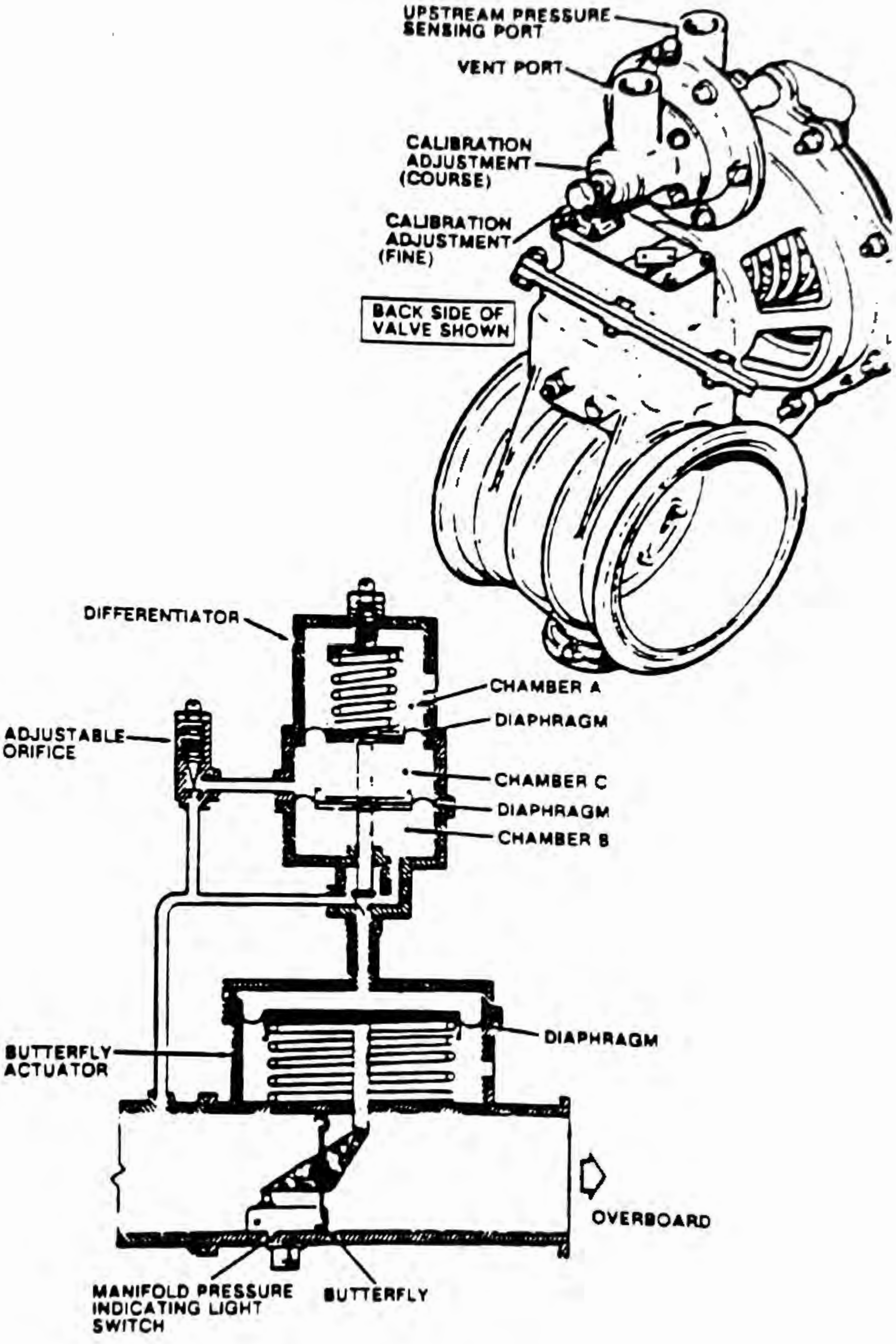
(e) When the pneumatic system shutoff switch is placed in the low or high positions (fire control handle in normal position), the open coil in the selector valve solenoid is energized and moves the selector valve to the on position. Upstream air, routed through the filter and the servo pressure regulator, is now directed by the selector valve to chamber A in the butterfly actuator assembly and chamber B is vented to atmosphere. The pressure applied to the diaphragm in chamber A will overcome the spring load. The diaphragm will move up and the actuator linkage will open the butterfly valve.

(f) The servo pressure regulator controls the flow of air to the actuator assembly. The pressure of the air passing through the servo pressure regulator is regulated by a diaphragm actuated poppet valve. The poppet valve varies the opening through which the air must flow to get to the actuator assembly. The poppet valve is controlled by a diaphragm which divides the upper portion of the pressure regulator into two chambers. Some of the air passing through the poppet valve is bled through an orifice into the lower chamber. This applies upstream air pressure to the under side of the diaphragm. An orifice in the body of the diaphragm allows air to bleed into the upper chamber, which is vented to atmosphere. When the pressure in the lower chamber of the pressure regulator increases, the diaphragm moves up. The poppet valve is moved to decrease the size of the opening the air must pass through, thereby decreasing the air pressure in the chambers of the actuator assembly. The poppet valve will seek a balanced position due to the bleed air passing into the upper chamber through the orifice in the diaphragm.

(g) When the actuator opens the butterfly valve, the downstream air pressure increases. Some of the downstream air is routed to the upper chamber of the differentiator assembly. At a predetermined downstream pressure level, the ball valve in the differentiator opens and air is bled from chamber A in the actuator assembly and vented to atmosphere. The butterfly valve is positioned to maintain a regulated downstream pressure by the force balance of the pressure in chamber A applied to the actuator diaphragm, which is opposed by the actuator spring. Two diaphragms, one large and one small, divide the differentiator into three chambers. Downstream air pressure is routed to the upper chamber, through an adjustable orifice, and into the middle chamber. The lower chamber is vented to atmosphere. When there is a sudden increase in downstream pressure, pressure builds up in the upper chamber first. The large diaphragm moves down, unseating the ball valve. Air will be bled from chamber A in the actuator assembly at a rate proportional to the rate of increase in downstream pressure. This will cause the butterfly valve to close sufficiently to reduce the downstream pressure. Should the downstream pressure suddenly decrease while the ball valve is open, pressure would be reduced in the upper chamber first because of the restricting orifice. The pressure in the middle chamber would act upon the large diaphragm to reduce quickly the rate at which air is bled from chamber A. A gradual increase in downstream pressure would cause the pressure in the upper and middle chambers to increase at approximately the same rate. Since the pressures in the upper and middle chambers will be equal, the large diaphragm will not transmit movement to the ball valve. The position of the ball valve would then be controlled by the small diaphragm, which produces smaller motions of the ball valve, thereby changing the pressure in chamber A slowly until a state of balance is established.

(h) The reverse flow check valve is divided into two chambers by a diaphragm. Upstream air pressure is routed to the lower chamber and downstream air pressure is routed to the upper chamber. If the upstream pressure falls within 0.25 psig or less of the downtream pressure, spring force moves the diaphragm down. The diaphragm unseats a poppet valve which allows air from chamber A in the actuator assembly to be vented to atmosphere. This causes the butterfly valve to close, preventing reverse airflow through the valve.

(3) Pneumatic Pressure Relief Valve (See Figure 36-12)



PRESSURE RELIEF VALVE

Figure 36-12

FTX80492

(a) A pressure relief valve is located on the centerline of the engine nacelle just under the forward end of the pylon on each engine, and is connected to the heat exchanger tee duct. The valve is a differential pressure butterfly-type valve, which prevents over-pressurizing the pneumatic system by venting to atmosphere upstream pressure in excess of 45.5 (±2) psig. During system surges, the valve might operate momentarily until the pressure regulator adjusts to the change in demand. During ground operation, the valve normally relieves at 45.5 to 47 psig. Over a wide range of conditions in flight, the relief valve limits system pressure from a minimum of 44.5 psig to a maximum of 49 psig, should the pressure regulator be inoperative. When the valve opens, a lever attached to the actuating mechanism actuates an electrical switch, which causes an indicating light on the system engineer's control panel to come on.

(b) The valve has two main housings, bolted together, which contain the valve subassemblies. An electrical connector is provided for the internal switch that activates the indicating light circuit. A vent port and a pressure sensing port are also provided.

(c) The relief valve consists of a differentiator and a butterfly actuator. The differentiator includes two spring-loaded diaphragms, an adjustable orifice, a bimetallic temperature compensator, and a poppet valve. The butterfly actuator contains a spring-loaded diaphragm, an actuating rod, a butterfly, a cam, and an electrical switch.

(d) The butterfly is spring-loaded to the closed position. The differentiator senses upstream air pressure through an external port in the valve body. The differentiator is divided into three chambers by two diaphragms, one large and one small. The upstream air is directed to the lower chamber (chamber B) and through an adjustable orifice into the middle chamber (chamber C). The upper chamber (chamber A) is vented to atmosphere. When upstream air is regulated to 38 (±2) psig or less, the relief valve is closed. If upstream pressure suddenly increases to 45.5 to 47 psig or more, pressure will build up in chamber B first. The large diaphragm instantly moves up and unseats the poppet valve, which admits pressure to the top of the actuator diaphragm at a rate proportional to the rate of increase of upstream pressure. The pressure overcomes the spring force and moves the actuator diaphragm down, which opens the butterfly to vent upstream pressure to atmosphere. If upstream pressure decreases suddenly while the poppet is open, pressure in chamber B drops rapidly. Pressure in chamber C then acts upon the large diaphragm to quickly close the poppet and reduce the rate at which upstream pressure in vented.

(e) A gradual increase in upstream pressure causes the pressure in chambers B and C to increase at approximately the same rate. Since the pressure in chambers B and C are equal, the large diaphragm does not transmit movement to the poppet valve. The position of the poppet valve is then controlled by the small diaphragm, which produces less movement. The pressure against the bottom of the actuator diaphragm increases slowly until a balanced condition exists. When the upstream pressure drops below 45.5 to 47 psig, air to the top of the actuator diaphragm is shut off and is vented to atmosphere. Spring force then closes the butterfly. The rate-type of control has a stabilizing effect on valve performance.

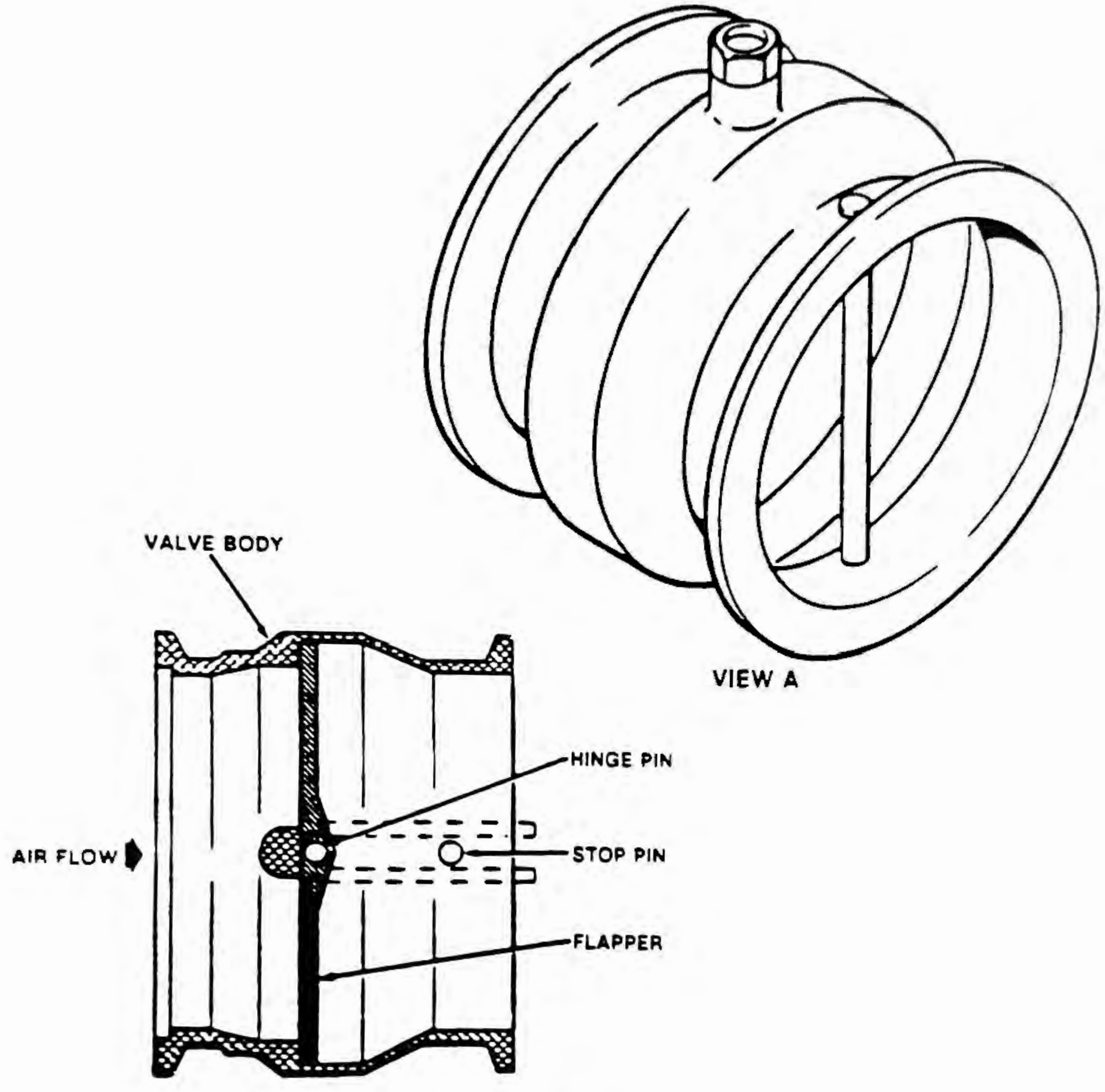
(4) Low-Pressure Bleed Check Valve (See Figure 36-13)

(a) A low-pressure bleed check valve is installed between the low-pressure bleed port duct of each engine and the bleed air tee duct. It is a pneumatically controlled, pneumatically actuated butterfly-type check valve.

(b) The valve is open when the pneumatic system is being supplied air from the low pressure compressors. When pneumatic system demands and/or controls cause the high pressure bleed shutoff valve to open, the higher pressures being supplied to the system downstream of the check valve actuate the valve to the closed position. This action prevents reverse air flow into the low pressure compressors.

(5) High Pressure Bleed Shutoff Valve (See Figure 36-14)

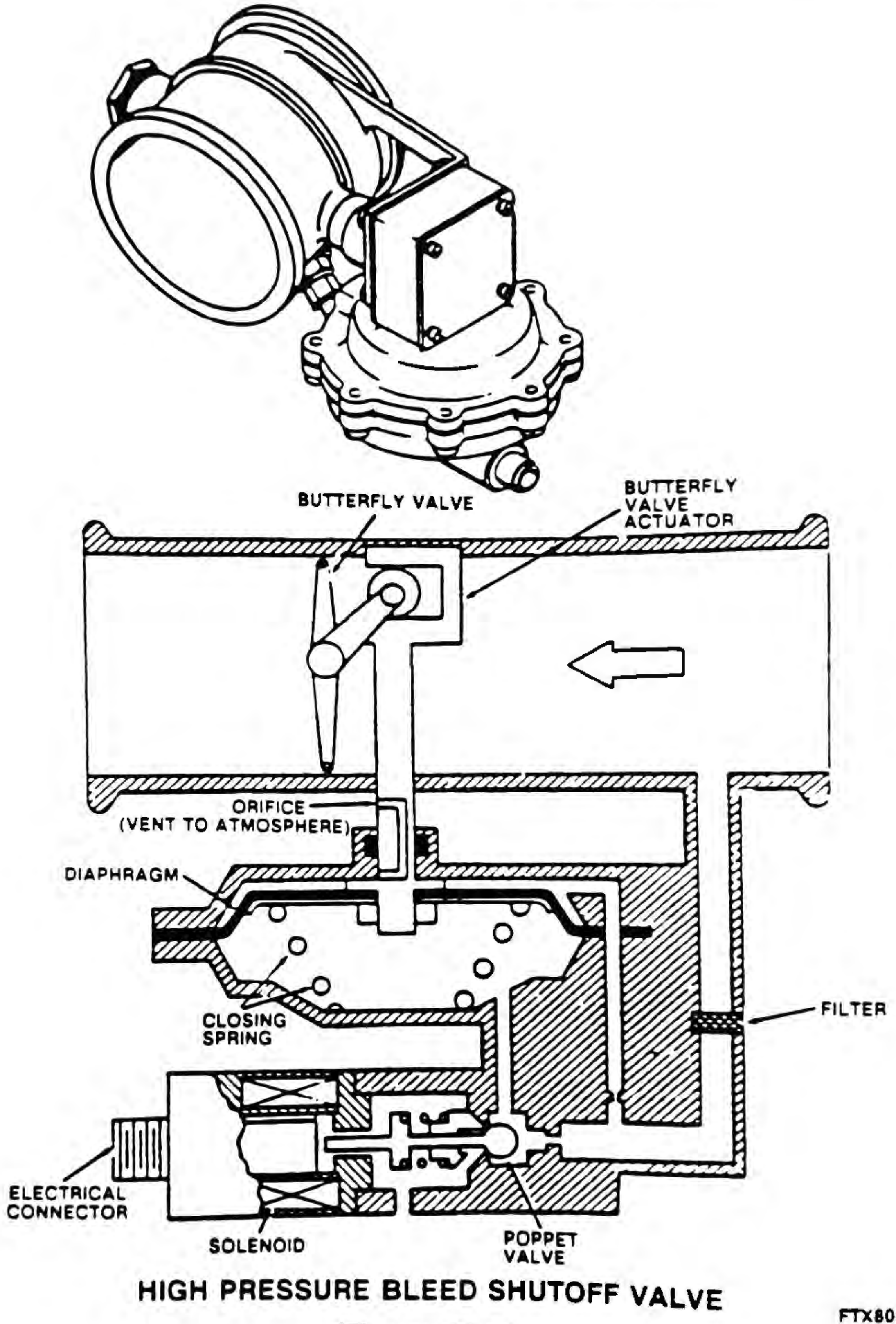
(a) A high pressure bleed shutoff valve is installed at approximately the 3-o'clock position, between the high pressure bleed duct and the bleed air tee duct, on each engine. The valve is an electrically controlled, pneumatically actuated, butterfly type valve.



LOW-PRESSURE BLEED CHECK VALVE

FTX80493

Figure 36-13



HIGH PRESSURE BLEED SHUTOFF VALVE

FTX80494

Figure 36-14

(a) The body of the valve consists of two housings, bolted together, containing the subassemblies of the valve. The valve has an electrical connector for the solenoid-operated poppet valve. Flanges at each end of the valve permit the use of clamps for installation.

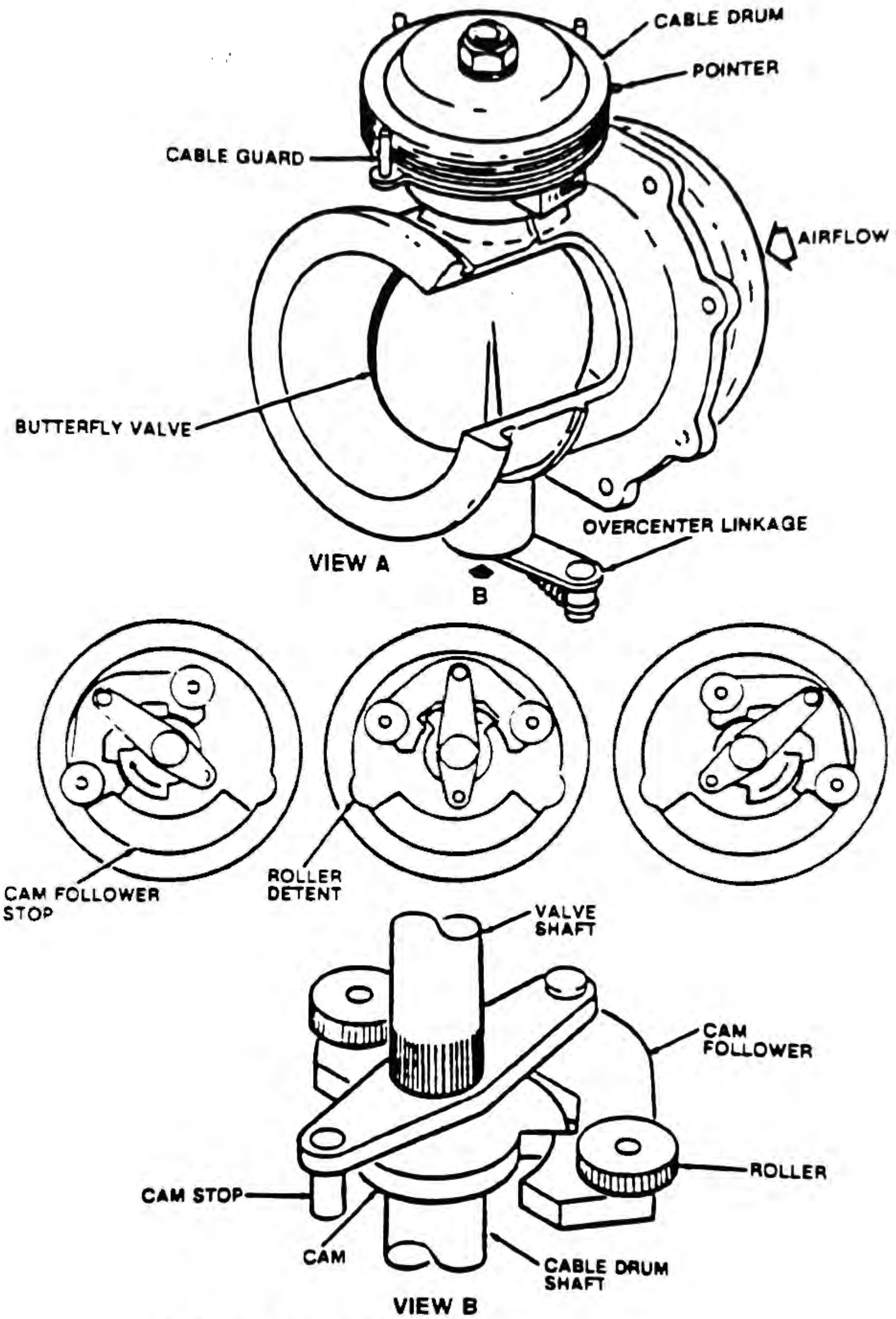
(b) The high pressure bleed shutoff valve is provided to control the supply of high pressure bleed air from the engine high pressure bleed ports to the pneumatic system. During ground operation the valve is controlled automatically or manually. During flight the valve is controlled manually.

(c) Operation of each valve is controlled by a corresponding throttle limit switch, engine ground control relay, and pneumatic system shutoff switch. With the engine operating, airplane on the ground (ground control relay energized), the throttle lever at a position between idle and approximately 1 9/16 inches from idle, and the system shutoff switch in low position the solenoid of the high pressure shutoff valve is energized and the valve is open. As the throttle is advanced past the 1 9/16 inches position from idle, the throttle limit switch is actuated and power to the solenoid is interrupted, closing the valve.

(d) During flight the valve is normally in the closed position, (system shutoff switch in the low position). If the demands made upon the pneumatic system are so great that an undertemperature or underpressure condition arises, the pneumatic system shutoff switch is placed in the high position. This action supplies electrical power to the solenoid of the shutoff valve and the valve opens to allow high pressure bleed air to enter the pneumatic system.

(e) With the pneumatic system shutoff switch in the low position during the final landing approach, the throttle limit switch is actuated (throttles advanced past a position approximately 1 9/16 inches from idle), and the engine ground control relay is deenergized. As the throttle is regarded, the limit switch is deactuated and when the ground control relay (controlled by the nose gear oleo switches) is energized during the landing roll, power is supplied to the solenoid of the shutoff valve and the valve opens.

(6) Engine Pneumatic Fire Shutoff Valve (See Figure 36-15)



ENGINE PNEUMATIC FIRE SHUT-OFF VALVE

Figure.36-15

FTX80495

(a) An engine pneumatic fire shutoff valve is installed in the wing leading edge between the pylon ducts and the pneumatic manifold. It is a cable-operated, butterfly-type valve. When closed, the valve prevents an engine fire from spreading through the pneumatic ducts by isolating the pylon ducts from the pneumatic manifold.

(b) The valve housing has a clamp-type mounting flange at each end and a bolt-type mounting flange near the valve inlet. An external pointer indicates the position of the butterfly valve and provides an index for valve rigging. Direction of airflow is indicated by an arrow on either side of the valve housing. An overcentering lever assembly at the bottom of the valve housing spring loads the valve to either the open or closed positions.

(c) The valve assembly includes the following components:

1 A radially serrated, pulley-locking hub

2 A cam-and-shaft assembly, which is splined to the pulley-locking hub

3 A cam follower assembly, consisting of a cam follower, tow rollers, a lever, and a cam stop pin

4 A cam follower stop

5 A butterfly valve

6 A butterfly valve shaft, which is splined to the cam follower assembly, to the butterfly valve, and to the overcentering lever assembly

7 An overcentering lever assembly, consisting of a lever, an anchor pin, and a spring

(d) Operation of the valve is controlled, through cables, by the associated fire shutoff handle located aft of the overhead switch panel. A cable drum is installed on the valve so that serrations in the cable drum mesh with serrations in the pulley-locking hub. When a fire shutoff handle is actuated, the cable rotates the cable drum at the valve assembly, which in turn rotates the pulley-locking hub. The hub turns the cam-and-shaft until the cam engages a slot in the cam follower assembly. The cam follower moves with the cam, causing the butterfly valve shaft to rotate. When the butterfly valve has reached the closed (or open) position, the cam follower strikes the cam follower stop and the leading roller falls into a recess in the valve housing. The cam follower swivels to permit the cam to disengage the slot. Further rotation of the cable drum does not cause further movement of the butterfly valve, although the cam might continue to travel until striking the cam stop pin. The cable drum and pulley-locking hub can rotate 186 degrees, divided as follows:

1 Pretravel - 10 degrees, while the valve is in the open position

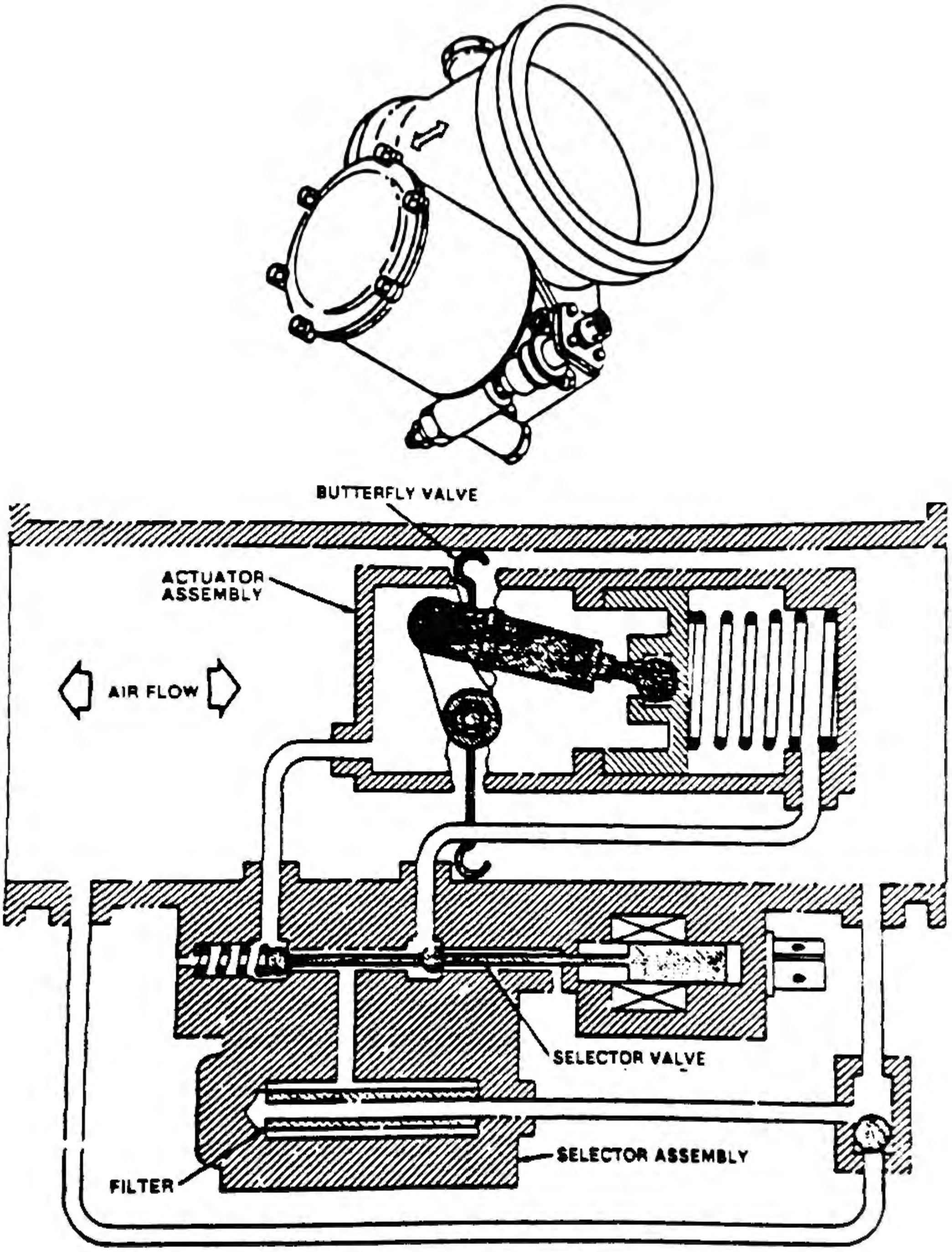
2 Operating Travel - 90 degrees, while the valve is closing

3 Overtravel - 86 degrees, while the valve is in the closed position The valve can be rigged without removing cable tension by loosening the nut attaching the cable drum and turning the pulley-locking hub.

(7) Manifold Crossfeed Valve (See Figures 36-16 and 36-17)

(a) A pneumatic manifold crossfeed valve is installed between the left and right sections of the pneumatic manifold on the centerline of the fuselage near the aft bulkhead of the cabin compressor compartment. It is an electrically controlled, pneumatically actuated butterfly-type valve. The valve operates to isolate the left and right sections of the pneumatic sections manifold (when closed) or to permit airflow between the left and right sections (when open).

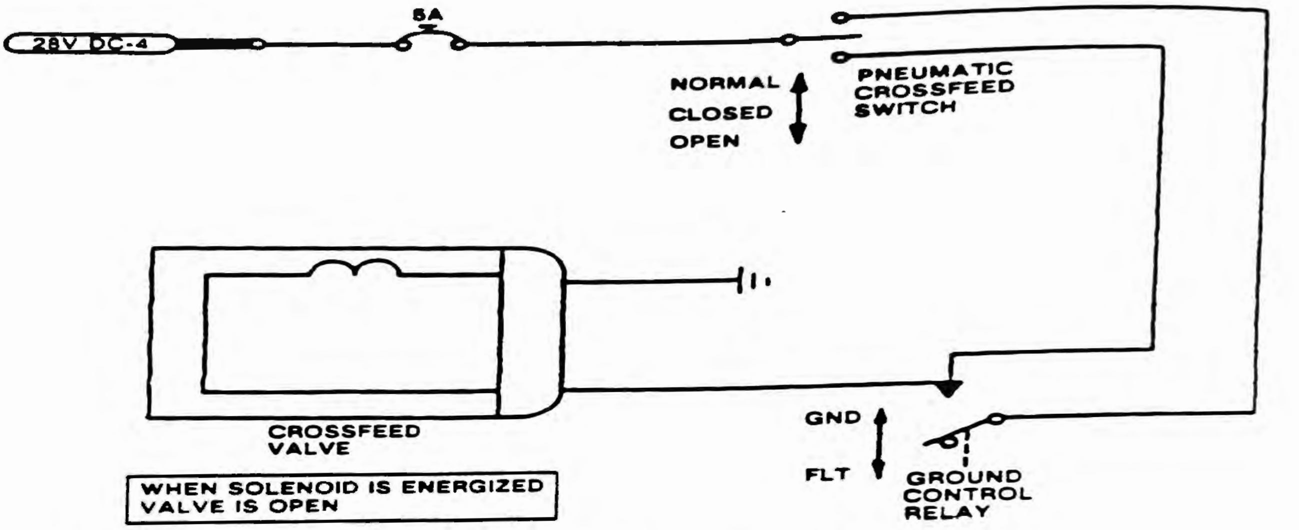
(b) The body of the valve consists of a butterfly valve housing and an actuator housing bolted together. The valve has a clamp-type mounting flange at either end and a triangular mounting lug opposite the actuator housing. An electrical connector and a solenoid-controlled selector valve are located on the actuator housing. A butterfly position indicator located on the actuator housing gives a mechanical indication of butterfly position.



MANIFOLD CROSSFEED VALVE

FTX80496

Figure 36-16



CROSSFEED VALVE ELECTRICAL CIRCUIT SCHEMATIC

FTX80497

Figure 36-17

(c) The valve assembly includes the following subassemblies:

1 A butterfly-valve actuator assembly, consisting of a spring-loaded piston, actuating linkage, and a butterfly valve

2 A solenoid-operated selector valve assembly, consisting of a solenoid, a spring-loaded double-ball valve, a filter, and a ball check valve

(d) With air pressure on either side of the butterfly valve and the solenoid deenergized, the double-ball selector valve is spring-loaded to the closed position. Air pressure is then routed from either of the pressure sense ports, through the ball check valve and filter, to the close side of the piston. The open side of the piston is vented to atmosphere. The butterfly valve is held closed by the combination of air pressure and spring force. When the coil of the solenoid is energized the selector valve is actuated. Air is then routed from the pressure sense ports, through the ball check valve and filter, to the open side of the piston. The close side of the piston is vented to atmosphere. The piston moves against the spring, opening the butterfly valve through linkage. The ball check valve allows air pressure from either side of the pneumatic manifold to operate the valve.

(e) The crossfeed valve control circuit includes a guarded switch, contacts of the No. 4 engine ground control relay and the solenoid in the crossfeed valve. During normal operation the crossfeed valve switch is placed in the normal position and opening and closing of the valve is controlled through the action of the ground control relay. With the airplane on the ground, the ground control relay is energized, electrical power is supplied to energize the crossfeed valve solenoid and the valve is open. If the left and right side pneumatic systems need to be isolated, placing the crossfeed valve switch in the closed position interrupts the power to the solenoid and the valve closes. Any time the solenoid is deenergized, the crossfeed valve is closed.

During flight the ground control relay is deenergized, power is not supplied to the solenoid and the crossfeed valve is closed. Placing the crossfeed valve switch in the open position supplies power directly to the crossfeed valve solenoid and the valve opens.

6. Temperature Regulation and Control

A. General

(1) The temperature control system regulates the manifold air temperature by controlling the flow of engine fan air through the heat exchanger located in the forward section of each pylon. This is done automatically by controlling the engine fan cooling air control valve.

(2) The temperature control system consists of a temperature thermistor, a temperature control amplifier, an engine fan cooling air control valve, and a heat exchanger for each engine.

B. Description

(1) Temperature Thermistor

There is a temperature thermistor located in each pylon duct downstream of the heat exchanger. The function of the temperature thermistor is to sense the outlet air temperature of the heat exchanger, and send this signal to the temperature control amplifier.

(2) Temperature Control Amplifier

The temperature controller amplifiers are located in the EPC aft equipment panel. Each amplifier is made up of a bridge-type sensing circuit, 2 magnetic amplifiers, 2 relays, and 2 radio noise filters. One amplifier and relay circuit functions to open the control valve, while the other functions to close the valve. Limit switches stop the valve motor at the fully opened or closed position. The temperature control amplifier regulates the output air temperature of the heat exchanger to remain within the range of 428° to 465°F.

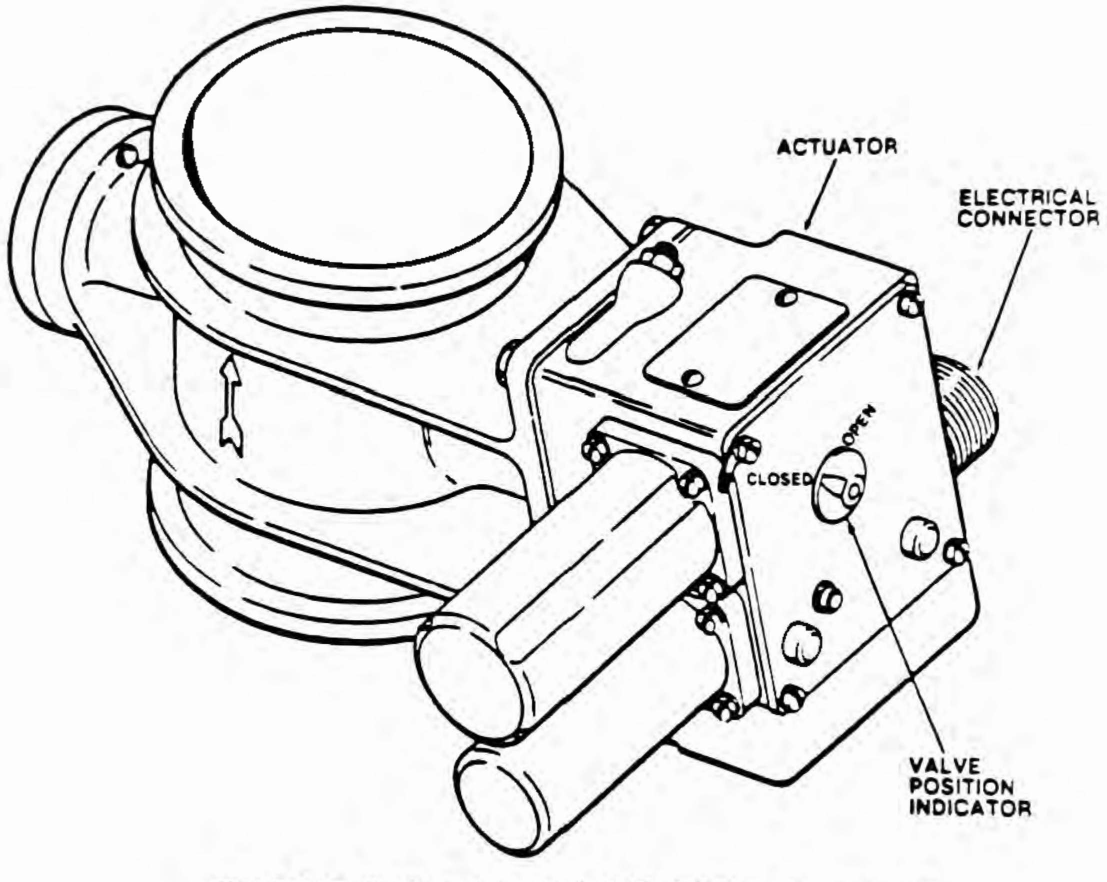
(3) Engine Fan Cooling Air Control Valve (See Figure 36-18)

There is an engine fan cooling air control valve located under the heat exchanger in each nacelle. The valve consists of a butterfly valve, actuated by a motor, which is controlled by the signal received from the temperature control amplifier. The function of the valve is to regulate the flow of engine fan cooling air through the heat exchanger.

(4) Heat Exchanger (See Figure 36-19)

(a) An air-to-air type heat exchanger is located in the forward end of each pylon. Pressure regulated engine bleed air at bleed port temperature is supplied to an inlet at the forward end of the heat exchanger.

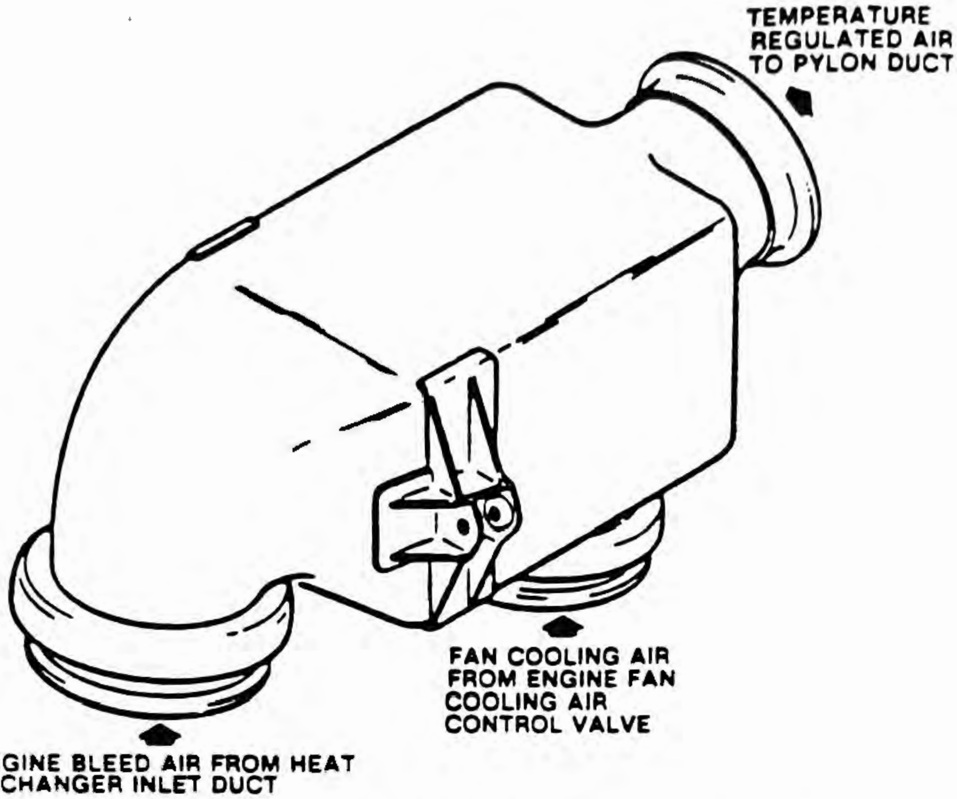
(b) Engine fan bleed air is used as a cooling medium as it flows through the heat exchanger. This cools the engine bleed air which then flows into the pylon duct at a regulated temperature within the range of 428° to 465°F.



ENGINE FAN COOLING AIR CONTROL VALVE

FTX80498

Figure 36-18


TEMPERATURE REGULATED AIR TO PYLON DUCT
FAN COOLING AIR FROM ENGINE FAN COOLING AIR CONTROL VALVE
ENGINE BLEED AIR FROM HEAT EXCHANGER INLET DUCT

ENGINE BLEED AIR HEAT EXCHANGER

FTX80499

Figure 36-19

(c) The heat exchanger is of platular design consisting of tube-in-plate elements. Bleed air passes through the tubes as cooling air passes over the exterior of the tubes and plates. The heat exchanger consists of a bleed air inlet, bleed air exit, engine fan cooling air inlet, and engine fan cooling air exit. After passing through the heat exchanger the cooling air is discharged into the pylon enclosure and then overboard through a fixed outlet.

7. Indicating

A. General

(1) The manifold air temperature warning lights indicate overtemperature in the pneumatic manifold.

(2) The manifold air temperature indicating system provides a continuous indication of the air temperature in the pneumatic manifold.

(3) The manifold air pressure indicating system provides a continuous indication of the left and right pneumatic manifold pressure.

(4) Other pneumatic indicating systems include the manifold air underpressure and relief valve indicating light, and manifold failure warning lights.

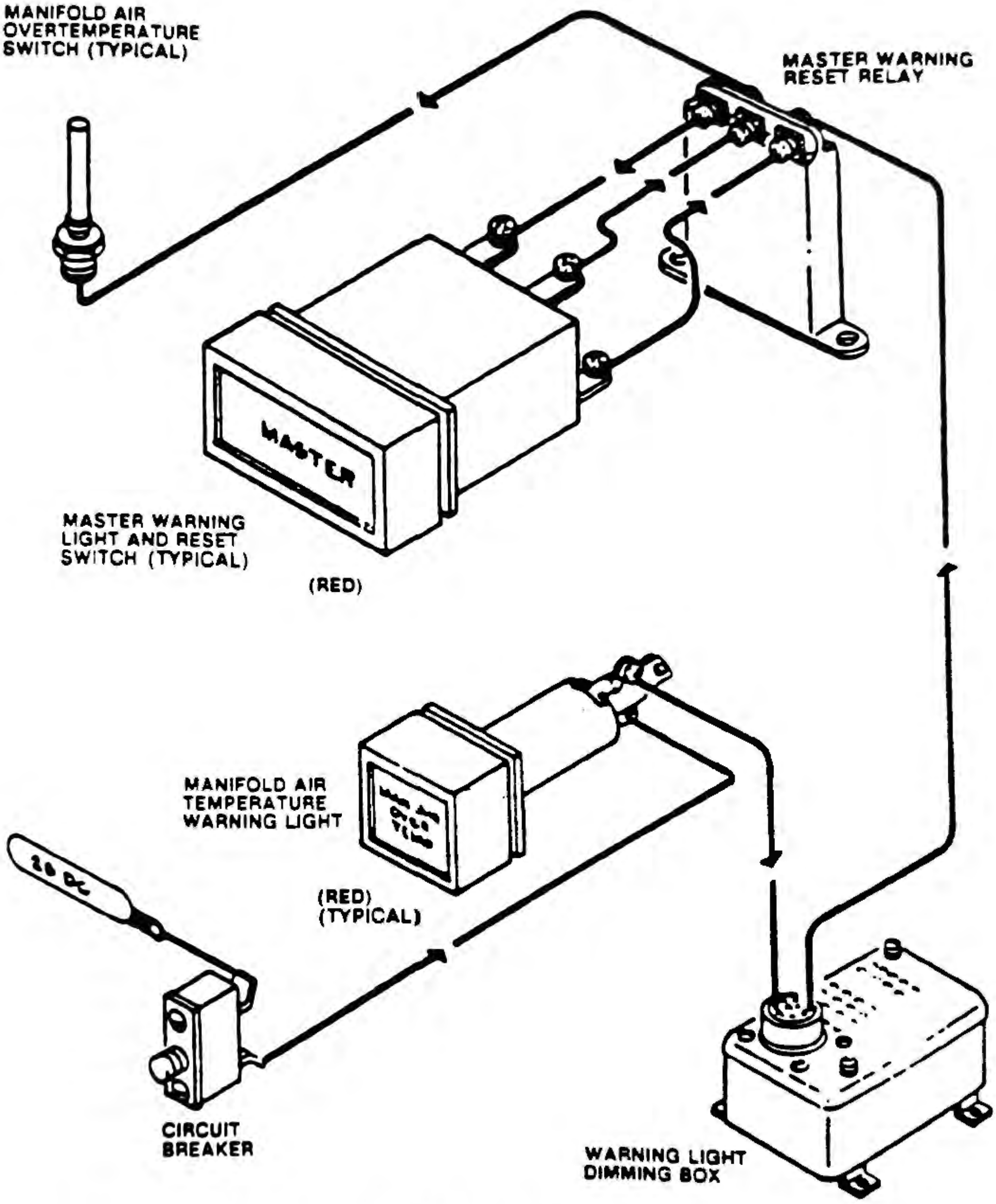
B. Description

(1) Manifold Air Abnormal Temperature Indicating (See Figure 36-20)

(a) Abnormal temperature indicating consists of four manifold air over-temperature warning lights installed on the systems engineer's control panel and four manifold air overtemperature switches which are installed in the left and right pneumatic manifold sections, one switch inboard of each pylon. The red lights are placarded MAN AIR OVER TEMP.

(b) When the temperature of the air flowing through the left or right sections of the pneumatic manifold rises to within the range of 246°C to 262°C, as indicated by the manifold air temperature indicator, the corresponding manifold air overtemperature switch closes. The switch completes a ground circuit to the red manifold air overtemperature warning light on the systems engineer's control panel and to the red master warning light on the glareshield. The master warning light reset switch can be used to turn off the master warning light so it can be operated by other warning systems. The manifold air overtemperature light goes off when the temperature drops below the 246°C and 262°C range.

(c) The overtemperature switch assemblies consist of a stainless steel tubular shell, containing the switch contacts and an externally threaded mounting nut. The contacts are mounted on, but insulated from, nickle-iron struts, which are connected to one end of the shell. The closing and opening of the contacts is governed by the expansion and contraction of the shell.


MANIFOLD AIR OVERTEMPERATURE SWITCH (TYPICAL)
MASTER WARNING RESET RELAY
MASTER
MASTER WARNING LIGHT AND RESET SWITCH (TYPICAL)
(RED)
MANIFOLD AIR TEMPERATURE WARNING LIGHT
(RED) (TYPICAL)
28 DC
CIRCUIT BREAKER
WARNING LIGHT DIMMING BOX

MANIFOLD AIR ABNORMAL TEMPERATURE INDICATING

FTX80500

Figure 36-20

(2) Manifold Air Temperature Indicating (See Figure 36-21)

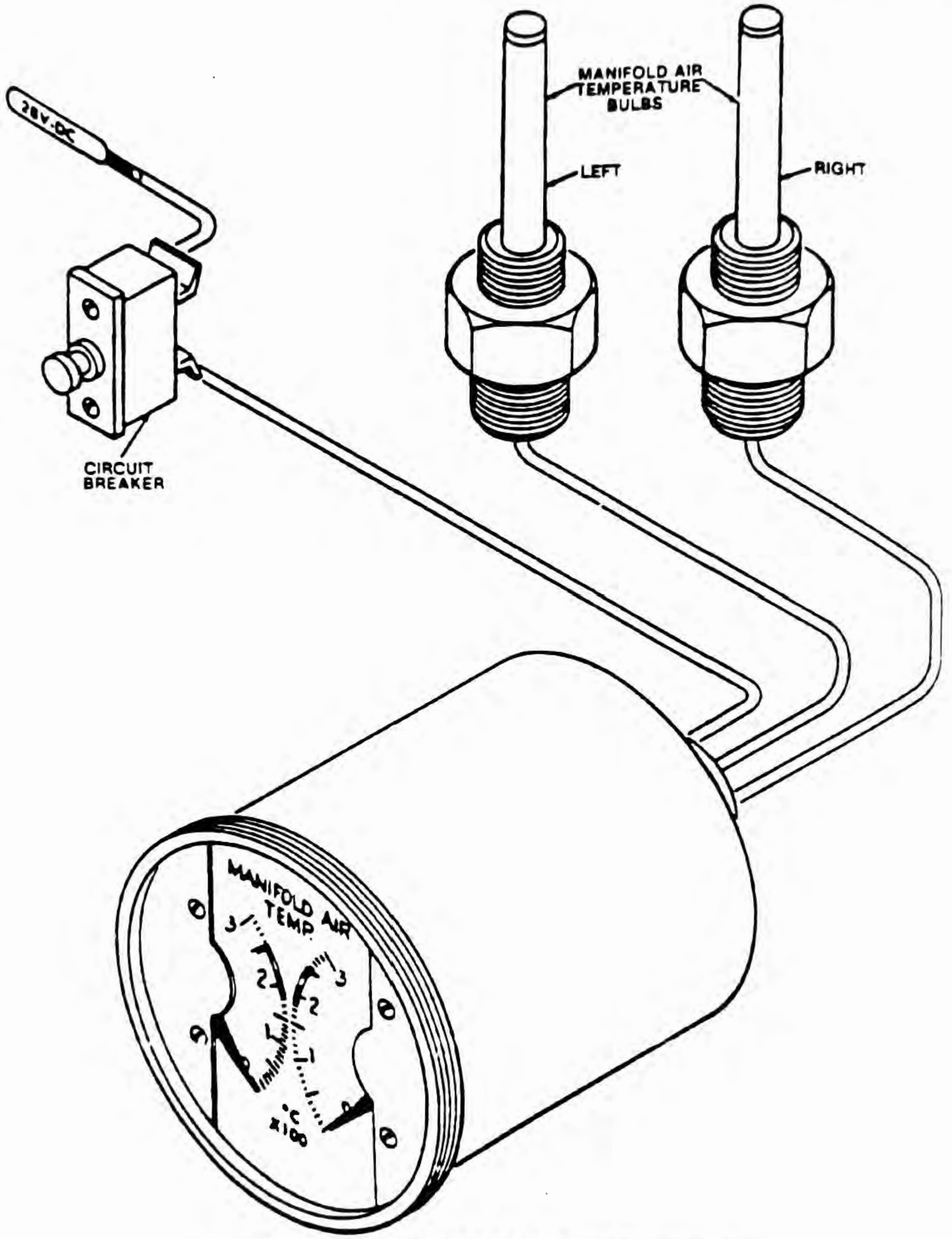
(a) The pneumatic manifold air temperature indicating system provides a continuous indication of the air temperature in the pneumatic manifold. The system consists of a dual ratiometer temperature indicator located on the systems engineer's panel and one temperature-sensing bulb installed in each half of the pneumatic manifold. The temperature-sensing bulbs are connected electrically to the indicator.

(b) The indicator has two scales, one for each section of the pneumatic manifold. The left scale indicates the temperature in the manifold inboard of engine 2. The right scale indicates the temperature inboard of engine 3. The indicator is calibrate in degrees centigrade from 0 to 3 multiplied by 100. Each scale has an undertemperature range indicated by a yellow arc from 182 to 214 degrees, a normal operating range indicated by a green arc from 214 to 242 degrees, and an overtemperature range indicated by a yellow arc from 242 to 258 degrees. A red radial at the 258-degree position indicates the upper limit of the overtemperature range.

(3) Manifold Air Pressure Indicating (See Figure 36-22)

(a) The manifold air pressure indicating system provides a continuous indication of the left and right pneumatic manifold pressure. The system consists of a standard, integrally lighted, dual manifold air pressure indicator, and a sense line connecting the indicator to the left and right pneumatic manifold pressure sensing ports and to a static reference source.

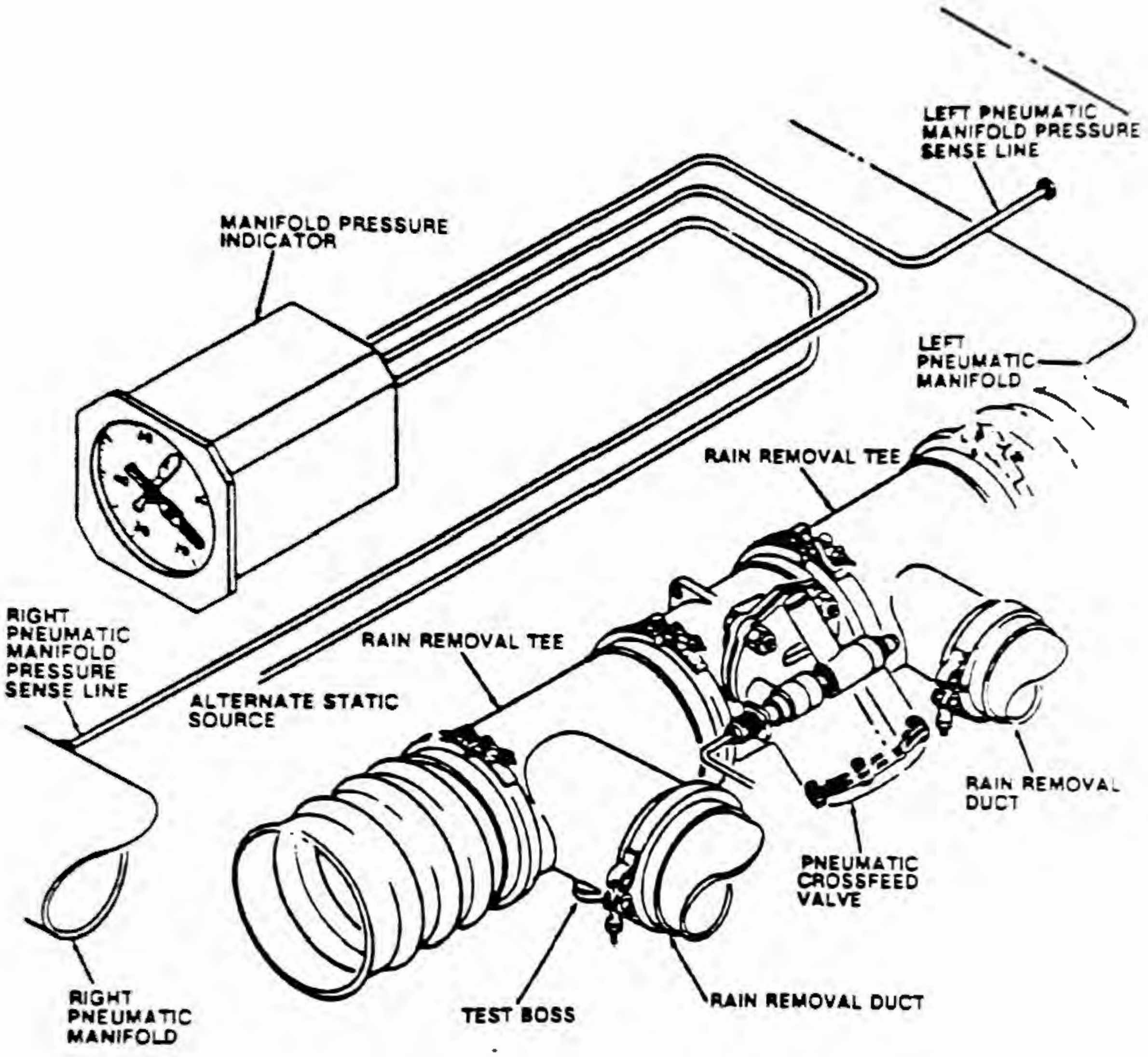
(b) The manifold pressure indicator is located on the systems engineer's panel. The indicator has two independent pointers on the dial and is calibrate in psig form 0 to 50. It is a mechanical pressure indicator and indicates the pressure in the corresponding half of the pneumatic manifold. The pressure sensing ports are located on each side of the pneumatic manifold crossfeed valve in the air conditioning compartment in the nose.



MANIFOLD AIR TEMPERATURE INDICATING

FTX80501

Figure 36-21



MANIFOLD AIR PRESSURE INDICATING

FTX80502

Figure 36-22

(4) Manifold Air Underpressure and Pressure Relief Valve Indicating

The manifold air underpressure indicating light switches are diaphragm-actuated, differential-pressure switches. They are installed approximately 12 inches to the left and right of the fuselage centerline, on the aft bulkhead of the cabin compressor compartment. The switch housing is a dome shaped enclosure, mounted on a square baseplate. A manifold pressure-sensing line is connected to a port in the bottom of the switch. An electrical receptacle is located at the top of the switch housing.

(a) The port admits manifold air pressure to the lower side of the diaphragm. Vents admit ambient air pressure to the upper side. If pressure in the manifold drops to within the range of 13.5 (±5) psig, or less, above the ambient air pressure, the diaphragm closes the switch contact. This action completes an electrical circuit to the manifold air pressure indicating light located on the systems engineer's control panel, causing the light to come on. The switch opens the circuit when the manifold air pressure rises to 15.5 psig above the ambient air pressure.

(b) The manifold air pressure indicating light is also electrically connected to the four pneumatic pressure relief valves. When the valve opens, the light comes on and remains on until the valve closes.

(5) Manifold Failure Indicating

(a) Manifold failure indicating is provided to indicate a rupture in the left or right pneumatic manifold ducts that are routed through the utility tunnel on each side of the forward cargo compartment and in the air conditioning accessory compartment. Each indicating circuit, one for the left manifold and one for the right manifold, consist of a warning light, amplifier, and sensing elements.

(b) The manifold failure sensing elements are located adjacent to and along the specified length of the manifold. In the event of a duct failure, the hot pneumatic air escaping from the duct is sensed by the manifold failure sensing elements. as the temperature increases, the resistance between the center core and the grounded outer jacket of the elements decreases. At a temperature of 255 (±12)°F (123.9 ±6.5°C), the resistance should be in the range of

75 to 170 ohms. The corresponding manifold rupture warning amplifier, located in the aft EPC equipment panel, senses this low resistance and applies 28 vdc to the corresponding manifold failure light located on the systems engineer's control panel and the light comes on. A circuit integrity check of each manifold failure indicating circuit may be performed by depressing the corresponding manifold failure light. This action provides the grounding circuit required for the amplifier to apply voltage for the light to come on.

PNEU CONTROL SWITCH POSITION	GROUND MODE		FLIGHT MODE	PNEU VALVES
	THROTTLE BELOW 18°	THROTTLE ABOVE 18°		
OFF	CLOSED	CLOSED	CLOSED	H.P. S/O
	CLOSED	CLOSED	CLOSED	PRESS. REG. AND S/O
LOW	OPEN	CLOSE	CLOSE	H.P. S/O
	OPEN	OPEN	OPEN	PRESS. REG. AND S/O
HIGH	OPEN	OPEN	OPEN	H.P. S/O
	OPEN	OPEN	OPEN	PRESS. REG. AND S/O

PRESSURIZATION REGULATOR & SHUTOFF VALVE OPERATIONS

FTX80503

Figure 36-23

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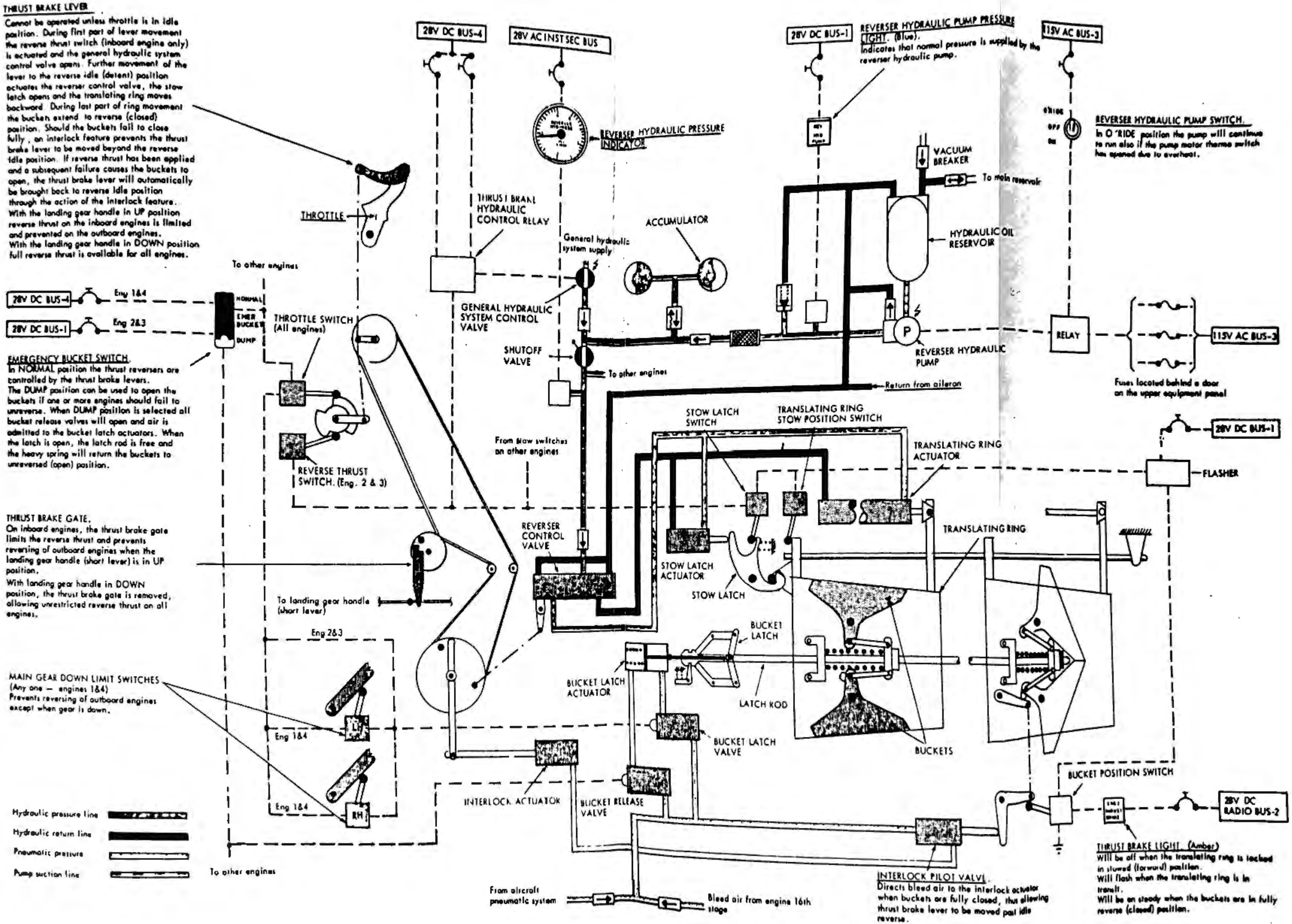


THRUST BRAKE LEVER

Cannot be operated unless throttle is in idle position. During first part of lever movement the reverse thrust switch (inboard engine only) is actuated and the general hydraulic system control valve opens. Further movement of the lever to the reverse idle (detent) position actuates the reverser control valve, the stow latch opens and the translating ring moves backward. During last part of ring movement the buckets extend to reverse (closed) position. Should the buckets fail to close fully, an interlock feature prevents the thrust brake lever to be moved beyond the reverse idle position. If reverse thrust has been applied and a subsequent failure causes the buckets to open, the thrust brake lever will automatically be brought back to reverse idle position through the action of the interlock feature.
With the landing gear handle in UP position reverse thrust on the inboard engines is limited and prevented on the outboard engines.
With the landing gear handle in DOWN position full reverse thrust is available for all engines.

EMERGENCY BUCKET SWITCH.

In NORMAL position the thrust reversers are controlled by the thrust brake levers.
The DUMP position can be used to open the buckets if one or more engines should fail to unreverse. When DUMP position is selected all bucket release valves will open and air is admitted to the bucket latch actuators. When the latch is open, the latch rod is free and the heavy spring will return the buckets to unreversed (open) position.

THRUST BRAKE GATE.

On inboard engines, the thrust brake gate limits the reverse thrust and prevents reversing of outboard engines when the landing gear handle (short lever) is in UP position.
With landing gear handle in DOWN position, the thrust brake gate is removed, allowing unrestricted reverse thrust on all engines.

MAIN GEAR DOWN LIMIT SWITCHES
(Any one — engines 1&4)
Prevents reversing of outboard engines except when gear is down.

REVERSER HYDRAULIC PUMP PRESSURE LIGHT. (Blue).
Indicates that normal pressure is supplied by the reverser hydraulic pump.

REVERSER HYDRAULIC PUMP SWITCH.
In O'RIDE position the pump will continue to run also if the pump motor thermo switch has opened due to overheat.

Fuses located behind a door on the upper equipment panel

INTERLOCK PILOT VALVE.
Directs bleed air to the interlock actuator when buckets are fully closed, thus allowing thrust brake lever to be moved past idle reverse.

THRUST BRAKE LIGHT. (Amber)
Will be off when the translating ring is locked in stowed (forward) position.
Will flash when the translating ring is in transit.
Will be on steady when the buckets are in fully reverse (closed) position.

Thrust brake system - schematic

-61 DIFFERENCES POWERPLANT

1. General - Description and Operation

A. Description (See Figures 71-1, 71-2, 71-3 & 71-4)

(1) The aircraft is powered by four Pratt & Whitney JT3D axial-flow turbofan engines. Each engine in the installed configuration is a demountable powerplant.

(2) The demountable powerplant is suspended from a pylon which extends below and partially forward of the wing leading edge by a three-point mounting system.

(3) The powerplant cowling sections join together around the engine and accessories forming a completely enclosed nacelle. This nacelle provided complete power plant protection and smooth, unobstructed airflow during flight.

(4) Each powerplant, after installation on the airplane, is protected by a fire detection system and a fire extinguishing system.

(5) The demountable powerplant, less the main cowl doors, has the following approximate weight.

(a) Total demountable powerplant weight, fully serviced, including nose cowl, thrust reverser, and exhaust nozzle - 6674 lbs.

(6) Individual major components of the powerplant have the following approximate weights.

(a) Nose cowl (complete assembly) - 300 lbs

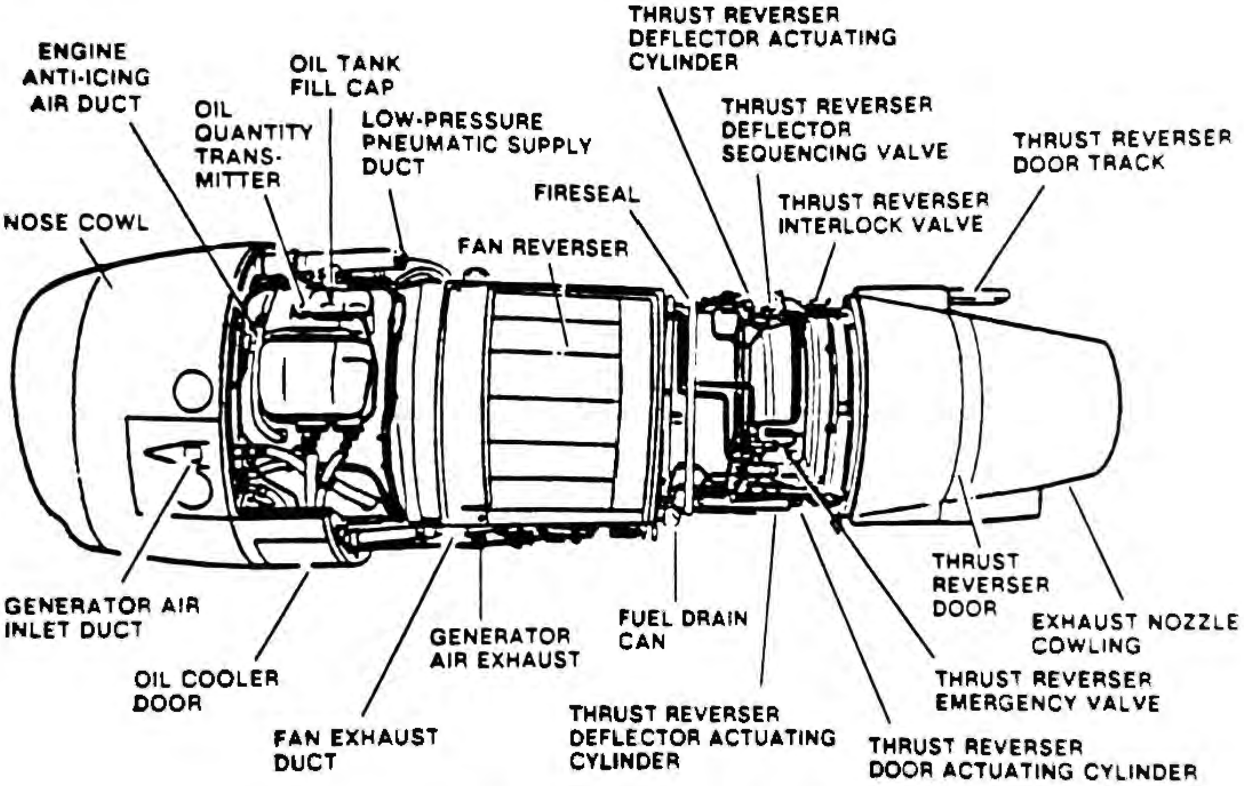
(b) Left forward cowl door - 49 lbs

(c) Right forward cowl door - 54 lbs

(d) Left upper center cowl door - 18 lbs

(e) Right upper center cowl door - 9 lbs

(f) Left lower center cowl door - 22 lbs


THRUST REVERSER DEFLECTOR ACTUATING CYLINDER
ENGINE ANTI-ICING AIR DUCT
OIL TANK FILL CAP
THRUST REVERSER DEFLECTOR SEQUENCING VALVE
OIL QUANTITY TRANSMITTER
LOW-PRESSURE PNEUMATIC SUPPLY DUCT
THRUST REVERSER DOOR TRACK
FIRESEAL
THRUST REVERSER INTERLOCK VALVE
NOSE COWL
FAN REVERSER
GENERATOR AIR INLET DUCT
OIL COOLER DOOR
GENERATOR AIR EXHAUST
FUEL DRAIN CAN
THRUST REVERSER DOOR
EXHAUST NOZZLE COWLING
THRUST REVERSER EMERGENCY VALVE
FAN EXHAUST DUCT
THRUST REVERSER DEFLECTOR ACTUATING CYLINDER
THRUST REVERSER DOOR ACTUATING CYLINDER

POWER PLANT -- LEFT SIDE

FTX80390(*)

Figure 71-1

(7) The demountable powerplant has the following approximate measurements.

(a) Total demountable powerplant length - 18 ft

(b) Maximum demountable powerplant diameter - 6 ft

(8) The powerplant, when intalled, has the following approximate height from the ground.

(a) Height from ground to outboard powerplant lowest point - 5 ft

(b) Height from ground to inboard powerplant lowest point - 3 ft

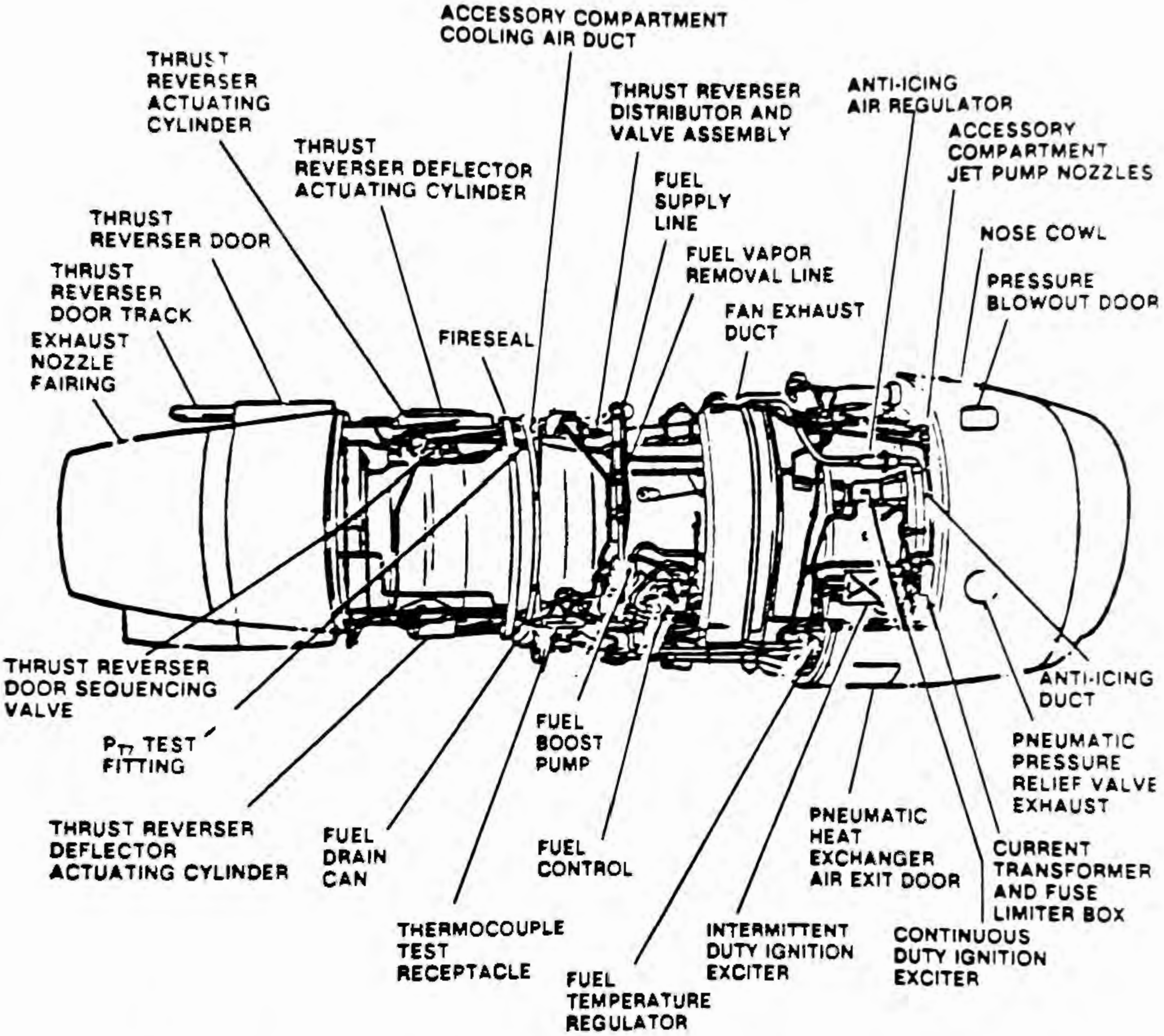
(9) The engine oil tank has the following approximate capacities:

Oil tank capacity	9.8 US gallons
Usable oil	9.7 US gallons
Expansion space (approximately 22 percent)	2.2 US gallons
Sump 0.1	US gallons

B. Exhaust

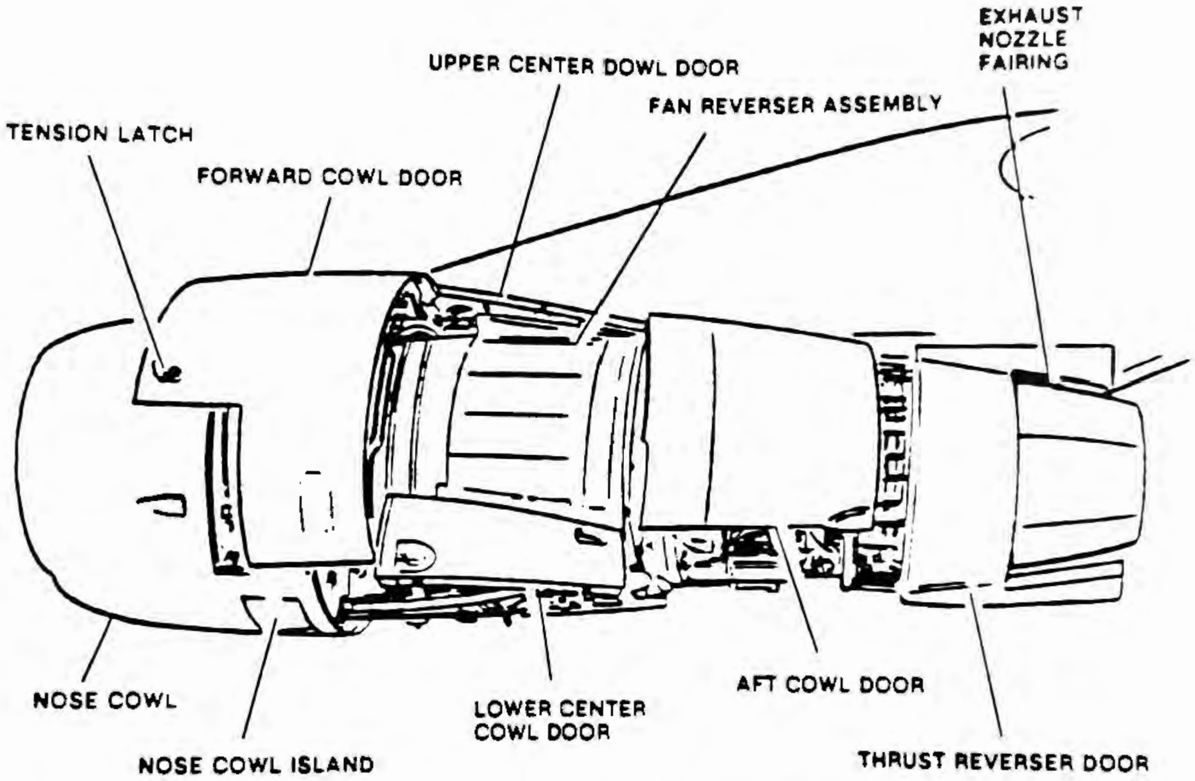
(1) Engine exhaust is ducted overboard through the exhaust nozzle. The exhaust nozzle is not an integral part of the thrust reverser and can be removed at field maintenance level.

(2) The thrust reverser consists of two reverser systems: primary and fan. The primary system is attached to the turbine exhaust case and reverses the primary exhaust system. The fan system reverses the engine fan discharge air. Both systems are pneumatically and simultaneously operated.


ACCESSORY COMPARTMENT COOLING AIR DUCT
THRUST REVERSER ACTUATING CYLINDER
THRUST REVERSER DISTRIBUTOR AND VALVE ASSEMBLY
ANTI-ICING AIR REGULATOR
ACCESSORY COMPARTMENT JET PUMP NOZZLES
THRUST REVERSER DEFLECTOR ACTUATING CYLINDER
FUEL SUPPLY LINE
THRUST REVERSER DOOR
NOSE COWL
FUEL VAPOR REMOVAL LINE
THRUST REVERSER DOOR TRACK
PRESSURE BLOWOUT DOOR
FAN EXHAUST DUCT
EXHAUST NOZZLE FAIRING
FIRESEAL
THRUST REVERSER DOOR SEQUENCING VALVE
ANTI-ICING DUCT
P_{T7} TEST FITTING
FUEL BOOST PUMP
PNEUMATIC PRESSURE RELIEF VALVE EXHAUST
THRUST REVERSER DEFLECTOR ACTUATING CYLINDER
FUEL DRAIN CAN
FUEL CONTROL
PNEUMATIC HEAT EXCHANGER AIR EXIT DOOR
CURRENT TRANSFORMER AND FUSE LIMITER BOX
THERMOCOUPLE TEST RECEPTACLE
INTERMITTENT DUTY IGNITION EXCITER
CONTINUOUS DUTY IGNITION EXCITER
FUEL TEMPERATURE REGULATOR

POWER PLANT -- RIGHT SIDE (FAN REVERSER REMOVED) FTX80393

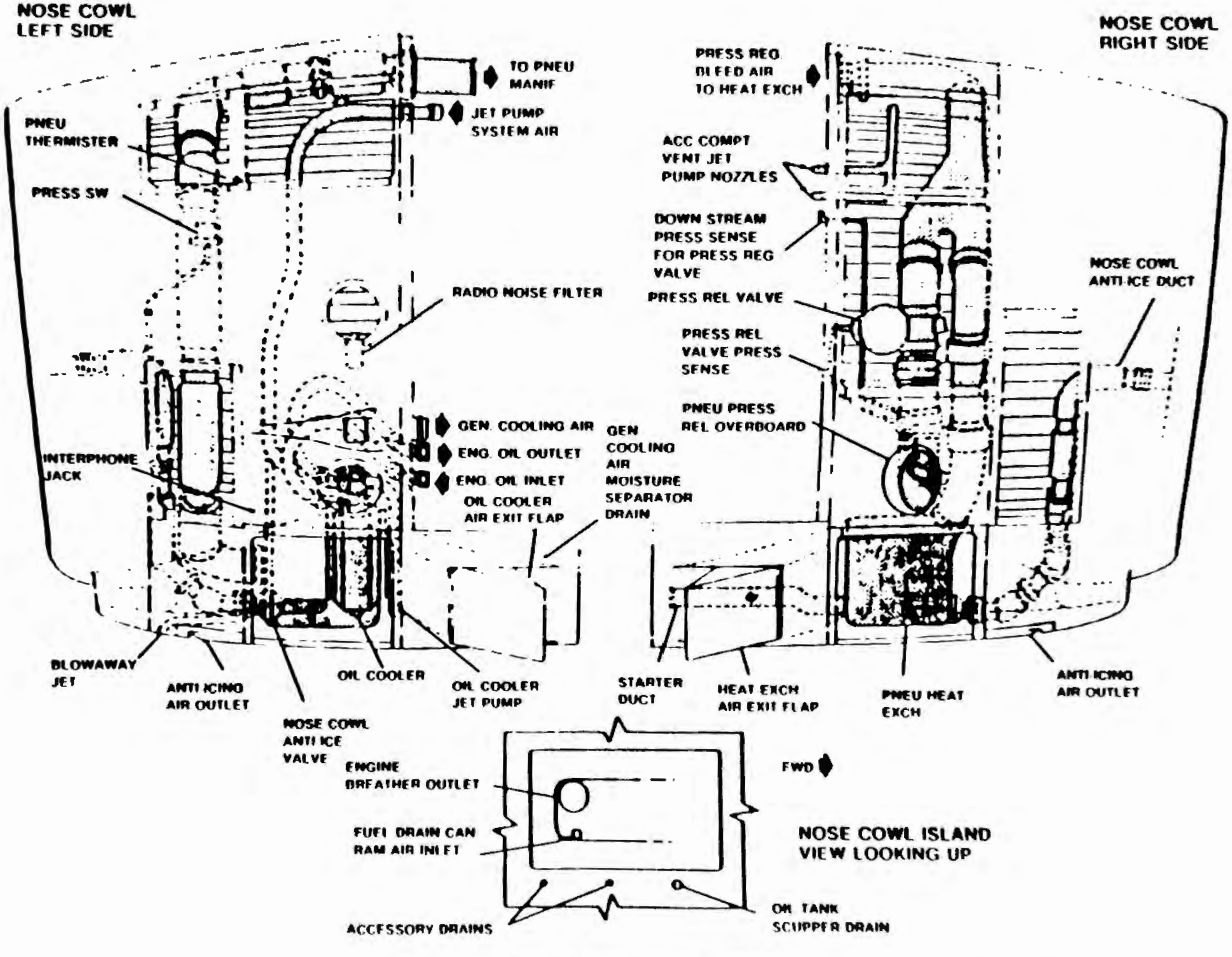
Figure 71-4



COWLING -- GENERAL LOCATION

FTX80394

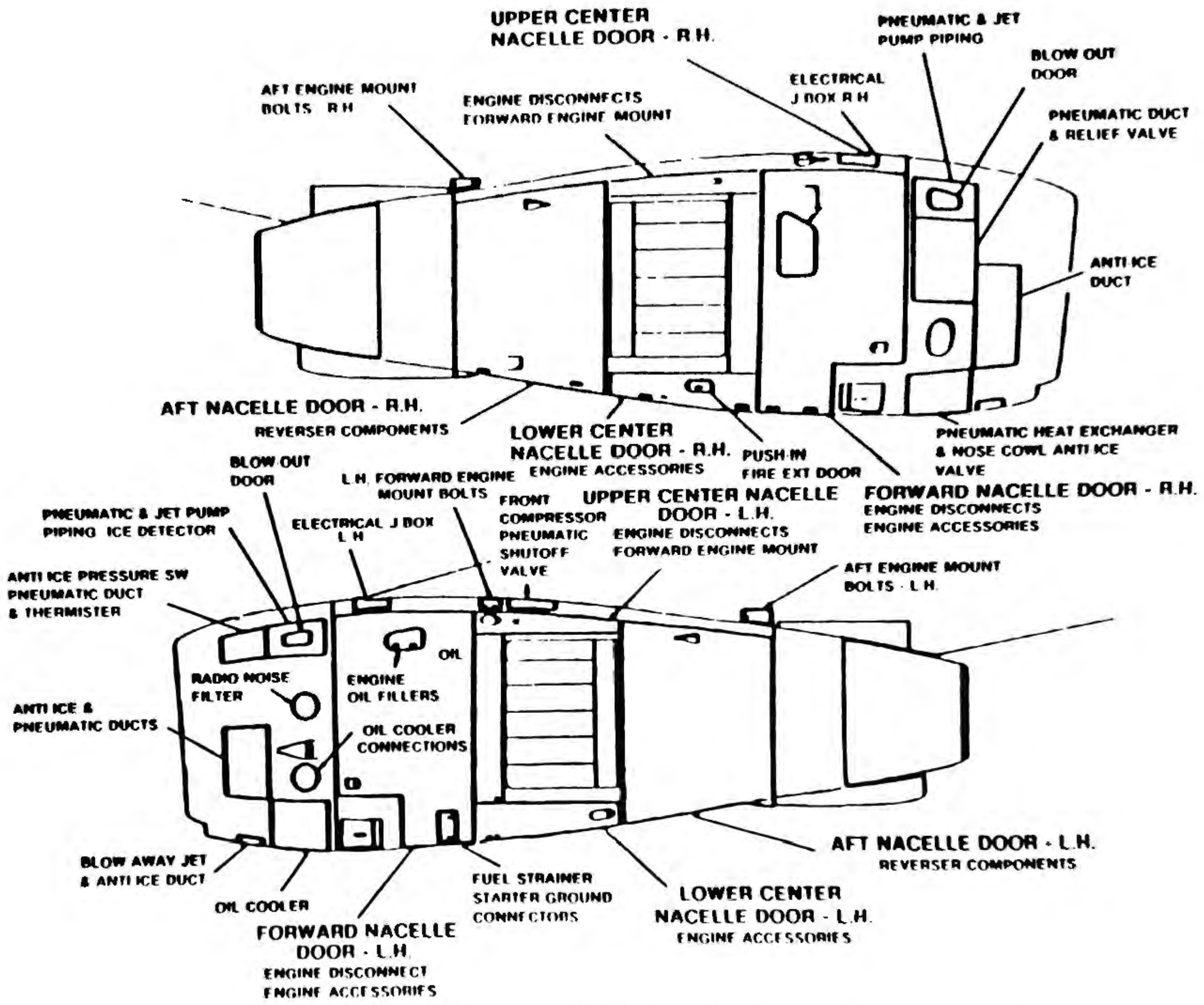
Figure 71-5



POWER PACKAGE NOSE COWL

FTX80396

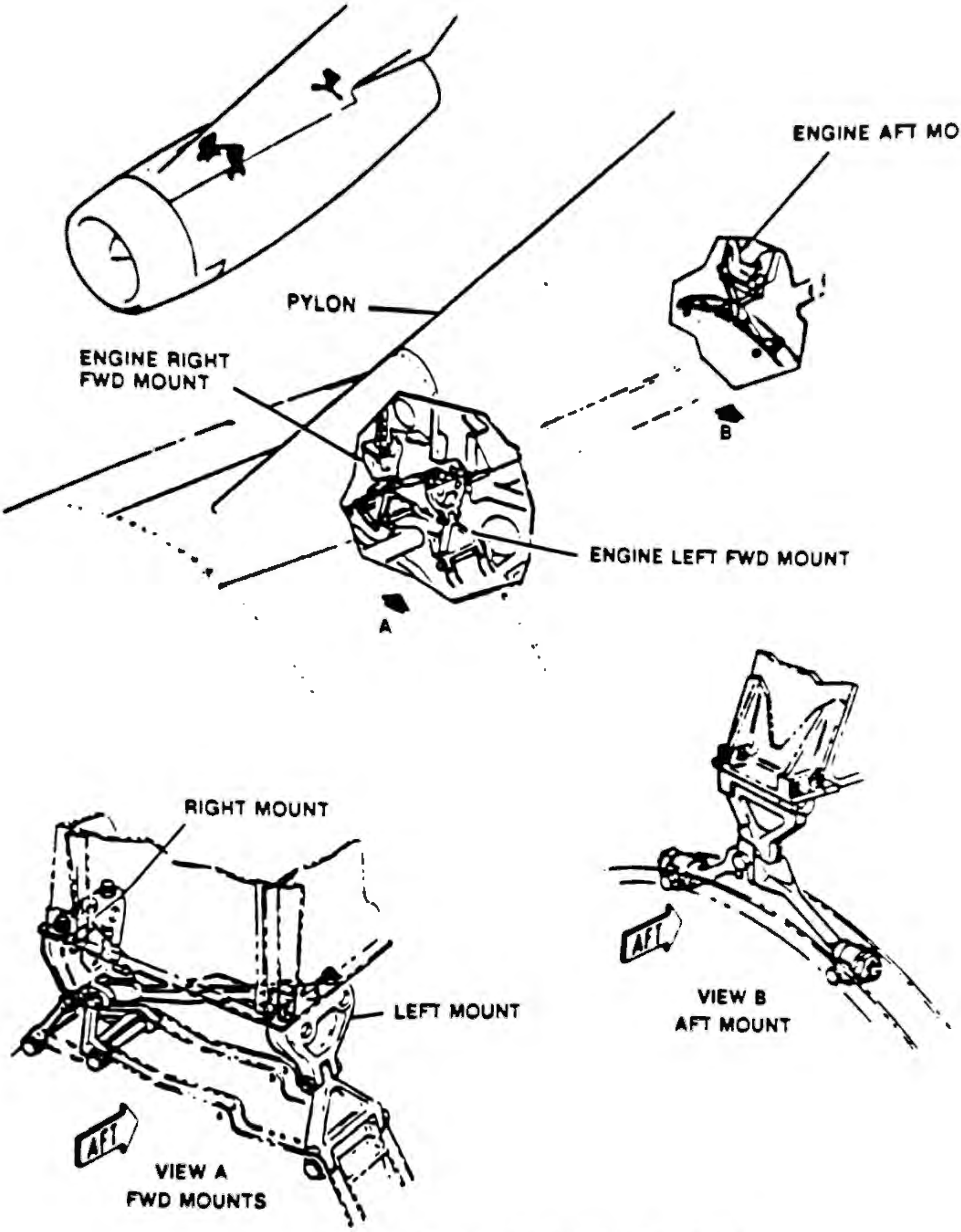
Figure 71-7


UPPER CENTER NACELLE DOOR - R.H.
PNEUMATIC & JET PUMP PIPING
BLOW OUT DOOR
ELECTRICAL J BOX R.H
AFT ENGINE MOUNT BOLTS R.H
ENGINE DISCONNECTS FORWARD ENGINE MOUNT
PNEUMATIC DUCT & RELIEF VALVE
ANTI ICE DUCT
AFT NACELLE DOOR - R.H.
REVERSER COMPONENTS
LOWER CENTER NACELLE DOOR - R.H.
ENGINE ACCESSORIES
PUSH IN FIRE EXT DOOR
PNEUMATIC HEAT EXCHANGER & NOSE COWL ANTI ICE VALVE
FORWARD NACELLE DOOR - R.H.
ENGINE DISCONNECTS
ENGINE ACCESSORIES
BLOW OUT DOOR
L.H. FORWARD ENGINE MOUNT BOLTS
FRONT COMPRESSOR PNEUMATIC SHUTOFF VALVE
UPPER CENTER NACELLE DOOR - L.H.
ENGINE DISCONNECTS
FORWARD ENGINE MOUNT
PNEUMATIC & JET PUMP PIPING ICE DETECTOR
ELECTRICAL J BOX L.H
AFT ENGINE MOUNT BOLTS - L.H.
ANTI ICE PRESSURE SW PNEUMATIC DUCT & THERMISTER
OIL
RADIO NOISE FILTER
ENGINE OIL FILLERS
ANTI ICE & PNEUMATIC DUCTS
OIL COOLER CONNECTIONS
AFT NACELLE DOOR - L.H.
REVERSER COMPONENTS
BLOW AWAY JET & ANTI ICE DUCT
FUEL STRAINER STARTER GROUND CONNECTORS
LOWER CENTER NACELLE DOOR - L.H.
ENGINE ACCESSORIES
OIL COOLER
FORWARD NACELLE DOOR - L.H.
ENGINE DISCONNECT
ENGINE ACCESSORIES

POWER PACKAGE ACCESS PANELS

FTX80397

Figure 71-8

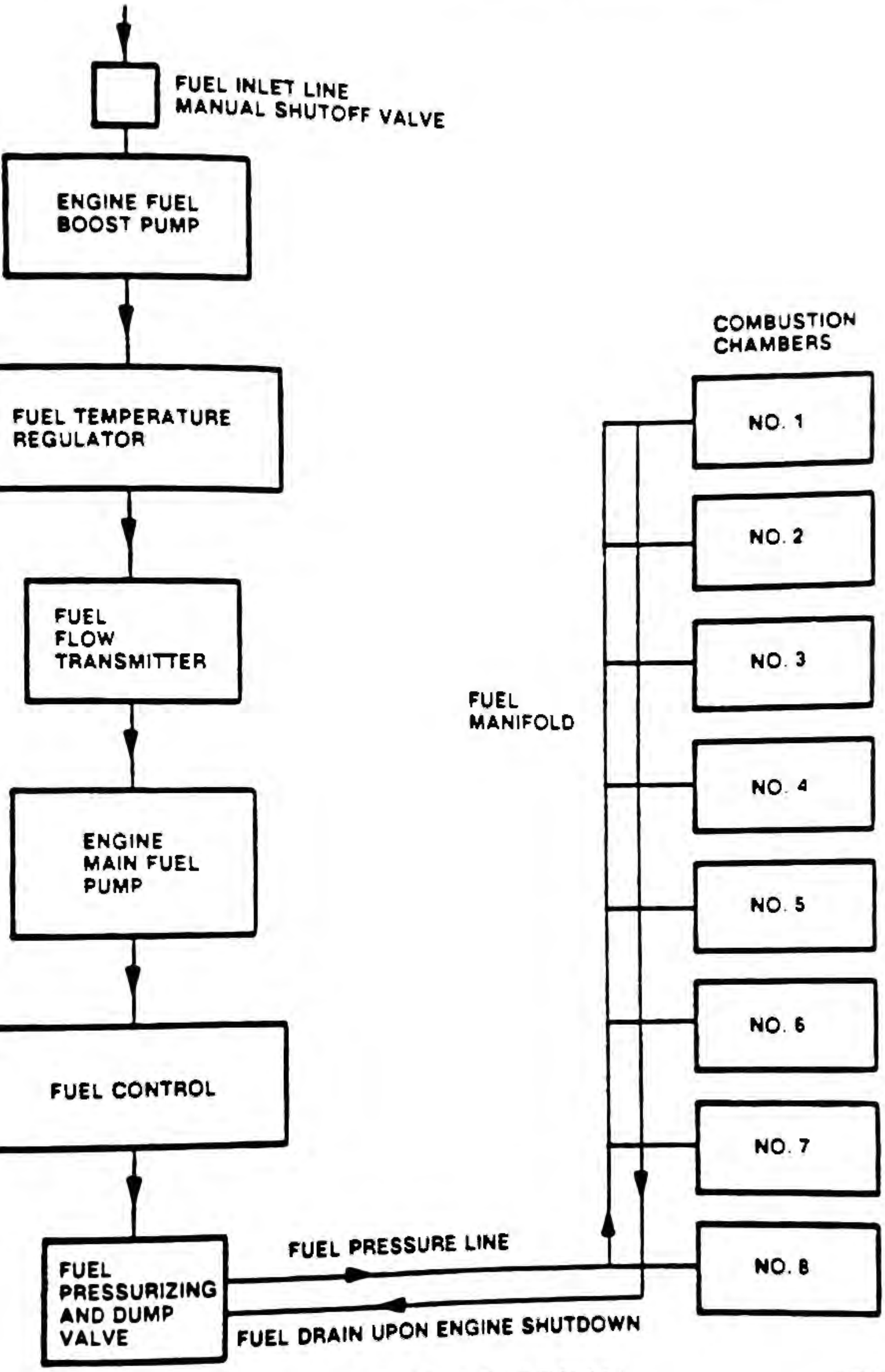


MOUNTS GENERAL LOCATION

FTX80398

Figure 71-9

-61 DIFFERENCES POWERPLANT

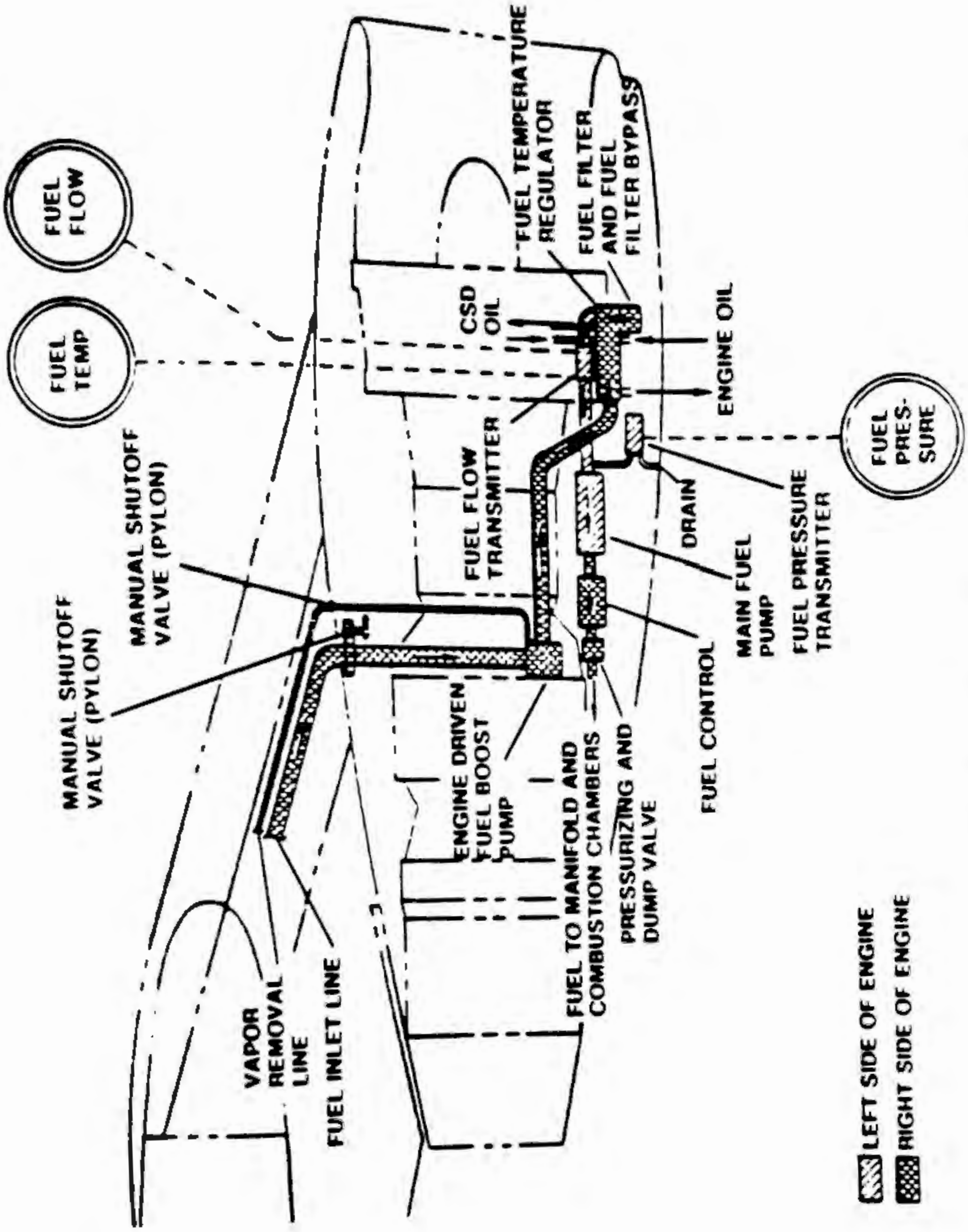


FUEL SYSTEM DIAGRAM

FTX80400

Figure 71-10

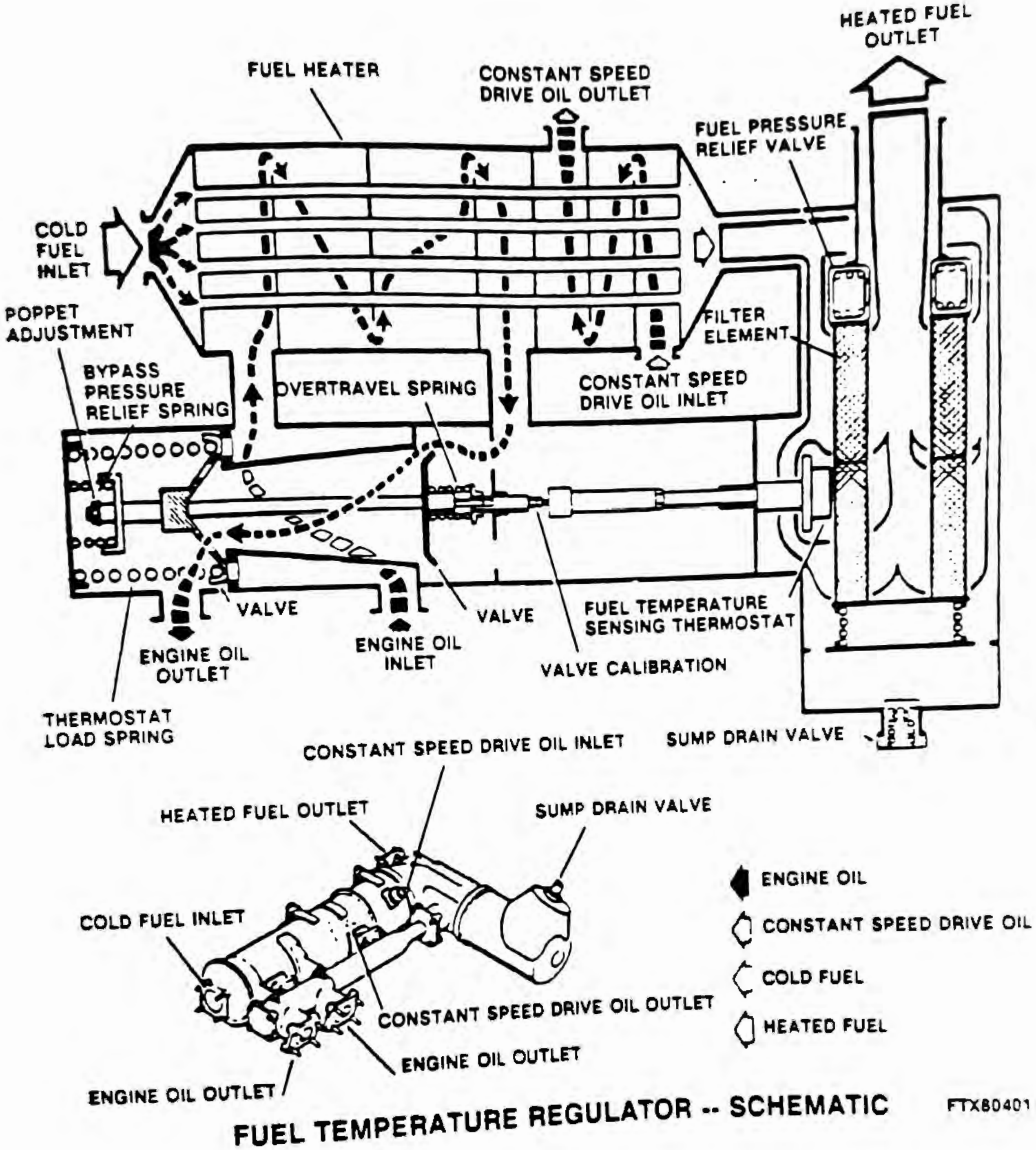
-61 DIFFERENCES POWERPLANT


FUEL FLOW
FUEL TEMP
MANUAL SHUTOFF VALVE (PYLON)
MANUAL SHUTOFF VALVE (PYLON)
VAPOR REMOVAL LINE
FUEL INLET LINE
ENGINE DRIVEN FUEL BOOST PUMP
FUEL FLOW TRANSMITTER
CSD OIL
FUEL TEMPERATURE REGULATOR
FUEL FILTER AND FUEL FILTER BYPASS
FUEL TO MANIFOLD AND COMBUSTION CHAMBERS
PRESSURIZING AND DUMP VALVE
FUEL CONTROL
DRAIN
MAIN FUEL PUMP
FUEL PRESSURE TRANSMITTER
ENGINE OIL
FUEL PRES-SURE
▨ LEFT SIDE OF ENGINE
▩ RIGHT SIDE OF ENGINE

FUEL SYSTEM -- SCHEMATIC

FTX80399

Figure 71-11



FUEL TEMPERATURE REGULATOR -- SCHEMATIC FTX80401

Figure 71-12

8. Fuel Control - Description and Operation

A. General

(1) The fuel control is designed to control the engine in either forward or reverse thrust operation under all operating conditions. Two control levers are provided; one a power lever, the other a shutoff lever. The power lever controls engine speed during all forward or reverse thrust operations. The shutoff lever controls engine starting and shutdown by opening or closing a fuel shutoff valve.

(2) The fuel control accurately governs the engine steady state selected speed, acceleration, deceleration, maximum burner pressure, thrust reversal, and provides a number of auxiliary signals. The speed governing system is of the proportional or droop type.

(3) The fuel control consists of a metering and a computing section. The metering section selects the flow rate of fuel to be supplied to the engine burners to provide the required engine thrust output, subject to engine operating limitations as sensed and scheduled by the fuel control computing section.

(4) The fuel control has a coarse and a fine filter. The coarse or main filter protects the metering section against damage by fuel contaminants. A bypass valve permits continued flow of fuel when the filter is clogged. The fine filter protects the computing section against damage by fuel contaminants. This filter is cleaned by the washing action of the fuel flow to the metering section.

(5) The major auxiliary system is the throttle-operated pilot valve which provides the shutoff signal to the minimum pressure and shutoff valve and a pressure signal to the manifold drain valve. The valve is positioned by a shutoff lever-operated cam to generate signals at the desired lever positions. The pilot valve also provides an engine windmill bypass feature when the shutoff valve is closed. This feature bleeds throttle valve downstream pressure to increase the throttle valve pressure drop. This allows the pressure regulating valve to continue normal operation and prevents damage to the pumps through excessive pressures during engine windmilling.

These rollers ride between the bellows-actuated lever and a multiplying lever. Thus, the force proportional to P_{t4} is transmitted through the rollers to the multiplying lever. Any change in the roller position (W_f/P_{t4}), or the P_{t4} signals, disturbs the equilibrium of the multiplying lever which results in the opening or closing of a variable or metering orifice that is supplied with regulated high pressure fuel through a fixed bleed orifice. The opening or closing of the metering orifice modulates fuel pressure between the two orifices, the pressure being used to control the position of a piston attached to the throttle valve plugger. The motion of this piston compresses or relaxes a spring which will return the multiplying lever to its equilibrium position.

(4) Deceleration control is accomplished by placing a minimum stop on the W_f/P_{t4} signal. This provides a linear relationship between W_f and P_{t4} which results in blowout-free decelerations.

9. Indicating - Description and Operation

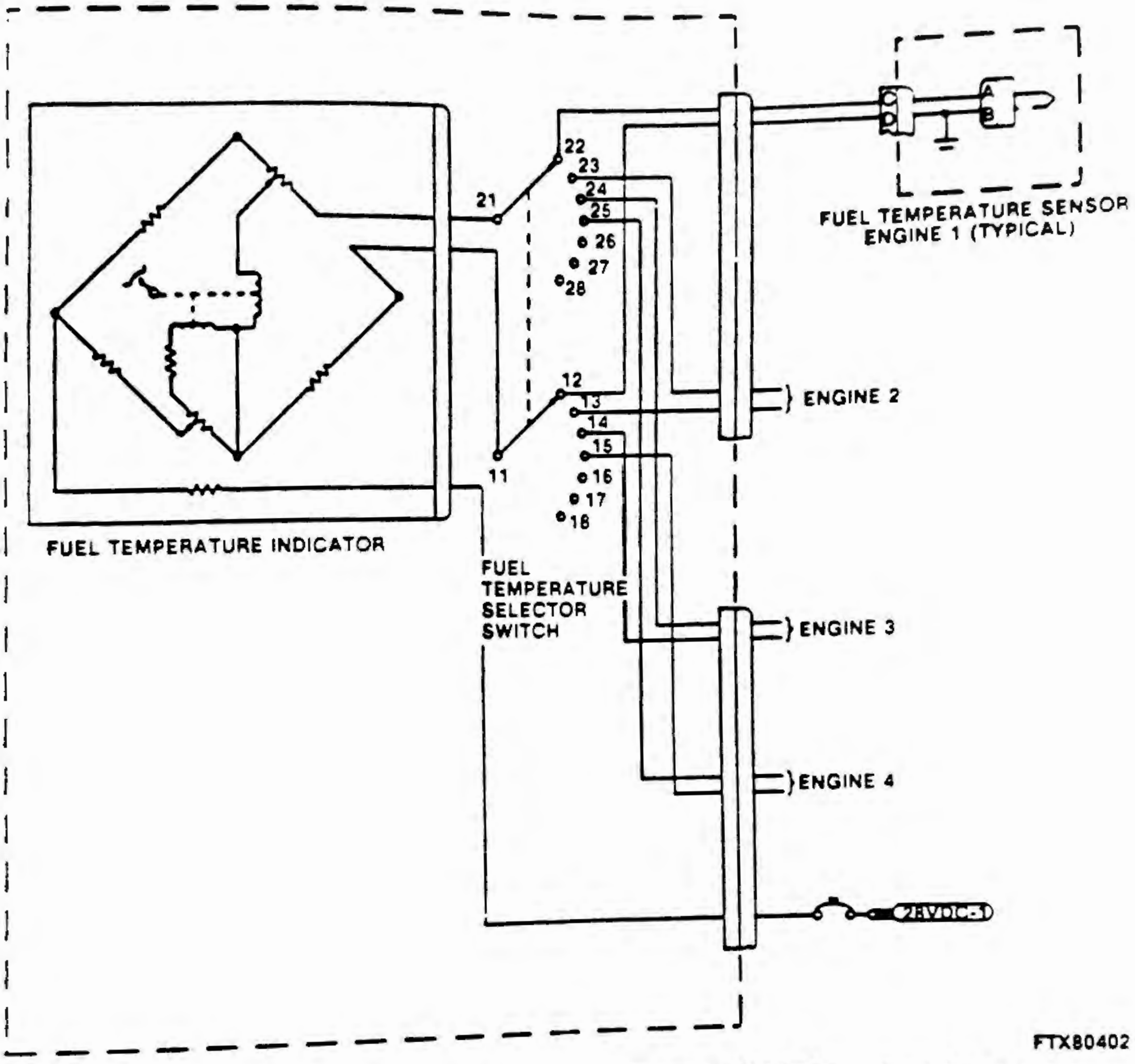
A. General

(1) Indicating systems are provided to monitor the engine fuel flow rate, temperature, and pressure.

B. Fuel Flow Indicating System

(1) The engine fuel flow indicating system provides a visual indication of engine fuel flow rate. The system consists of a transmitter, secured to the fuel temperature regulator located on the forward underside of the engine, and an indicator mounted on the instrument panel in the flight compartment. The system is supplied with 115 VAC through a circuit breaker located on the main circuit breaker panel.

(2) The fuel flow transmitter measures the flow rate of fuel consumed by the engine and provides a start and stop pulse output that is proportional to the measured mass fuel flow. The transmitter consists of a spring assembly, a swirl cap, rotor and magnet assembly that creates the start pulse, and a spring restrained turbine that creates the stop pulse. The fuel flow transmitter requires no electrical power for its operation.


FUEL TEMPERATURE INDICATOR
21
22
23
24
25
26
27
28
12
13
14
15
16
17
18
11
FUEL TEMPERATURE SELECTOR SWITCH
C
D
A
B
FUEL TEMPERATURE SENSOR ENGINE 1 (TYPICAL)
ENGINE 2
ENGINE 3
ENGINE 4
28VDC-1

FTX80402

ENGINE FUEL TEMPERATURE INDICATING SYSTEM -- SCHEMATIC

Figure 71-13

E. Operation

(1) A start and stop pulse from the fuel flow transmitter is fed to the fuel flow indicator micro processor. The fuel flow indicator processes the start and stop pulse and calculates the flow rate, then, using a crystal timebase, integrates the rate to derive fuel used.

(2) When the fuel temperature indicating system selector switch is positioned to obtain a desired engine fuel temperature, the temperature sensor on that engine is connected to the fuel temperature indicator. A change in fuel temperature changes the resistance of the sensor, which unbalances the bridge circuit. Bridge imbalance changes the current flow through the motor windings and the magnetic field acting on the motor armature, causing movement of the indicator pointer and dial indication of fuel temperature.

(3) The fixed coils in the fuel pressure transmitter and indicator are interconnected by three unshielded wires to form an AC bridge. With the pressure applied to the transmitter is unchanged, the bridge is electrically balanced and no current flows through the moving coil of the indicator. When pressure increases or decreases, the diaphragm in the transmitter moves the armature, thus changing the reluctance of the transmitter coils and unbalancing the bridge. This unbalance results in a current flow and accompanying torque in the movable coil of the indicator. The coil with its attached pointer turns until the torque is zero and the bridge is again balanced. Dial markings on the indicator show the position assumed by the pointer for the various applied pressures.

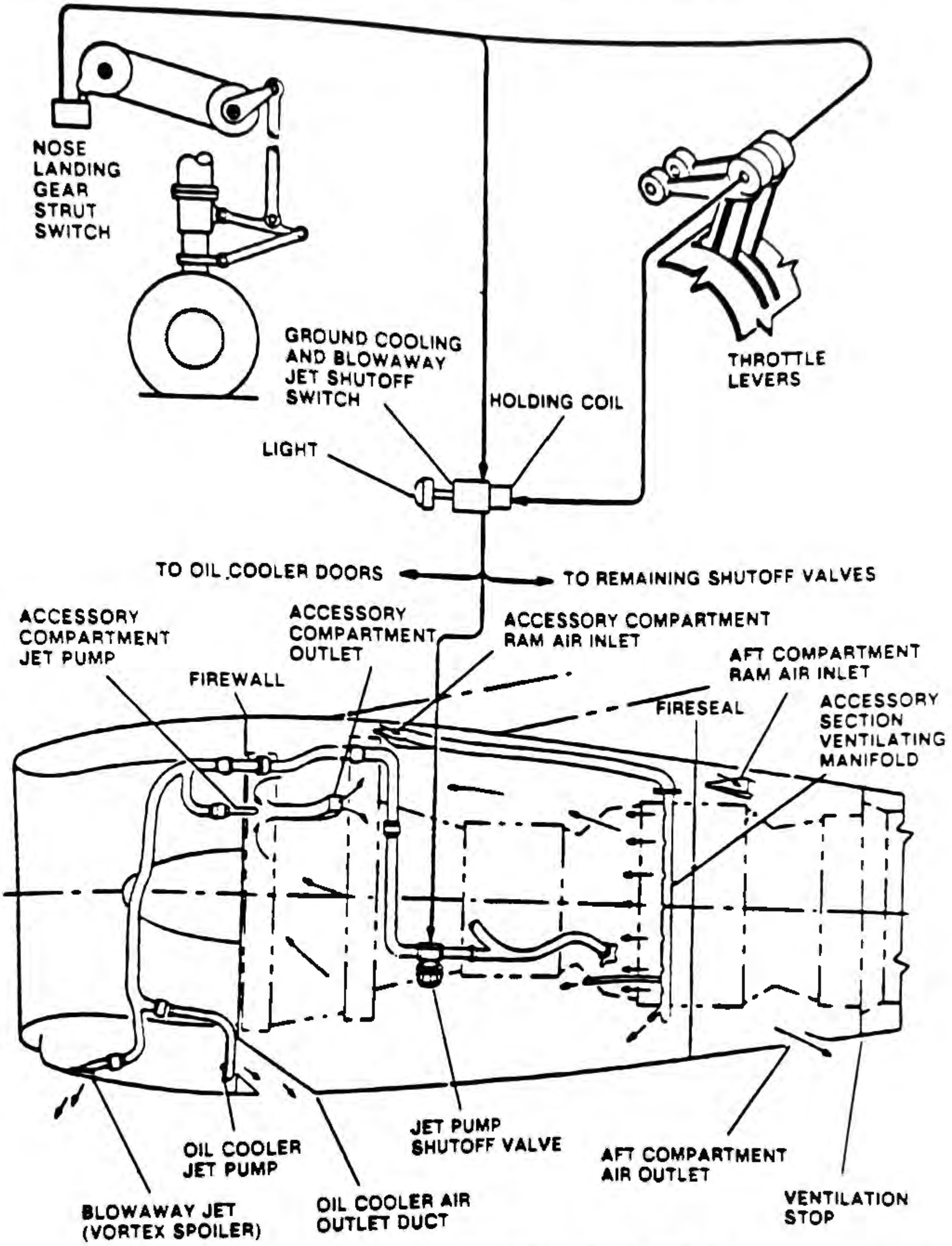
10. General - Description and Operation

A. Description

(1) The engine air system outlined in this chapter consists of engine accessory cooling. All systems are identical for each engine.

(2) Accessory cooling is provided by a jet pump system on the ground and by ram air during flight.

-61 DIFFERENCES POWERPLANT


NOSE LANDING GEAR STRUT SWITCH
THROTTLE LEVERS
GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
HOLDING COIL
LIGHT
TO OIL COOLER DOORS
TO REMAINING SHUTOFF VALVES
ACCESSORY COMPARTMENT JET PUMP
ACCESSORY COMPARTMENT OUTLET
ACCESSORY COMPARTMENT RAM AIR INLET
FIREWALL
AFT COMPARTMENT RAM AIR INLET
FIRESEAL
ACCESSORY SECTION VENTILATING MANIFOLD
JET PUMP SHUTOFF VALVE
OIL COOLER JET PUMP
AFT COMPARTMENT AIR OUTLET
BLOWAWAY JET (VORTEX SPOILER)
OIL COOLER AIR OUTLET DUCT
VENTILATION STOP

ACCESSORY COOLING -- SCHEMATIC FTX80405

Figure 71-15

(e) Removing electrical power from the solenoid positions the pilot valve in the normally closed position, causing an equalization of pressure in the valve central chamber. With the valve pressure equalized, the spring closes the valve disc, cutting off pneumatic pressure to the ground cooling and blowaway jet system.

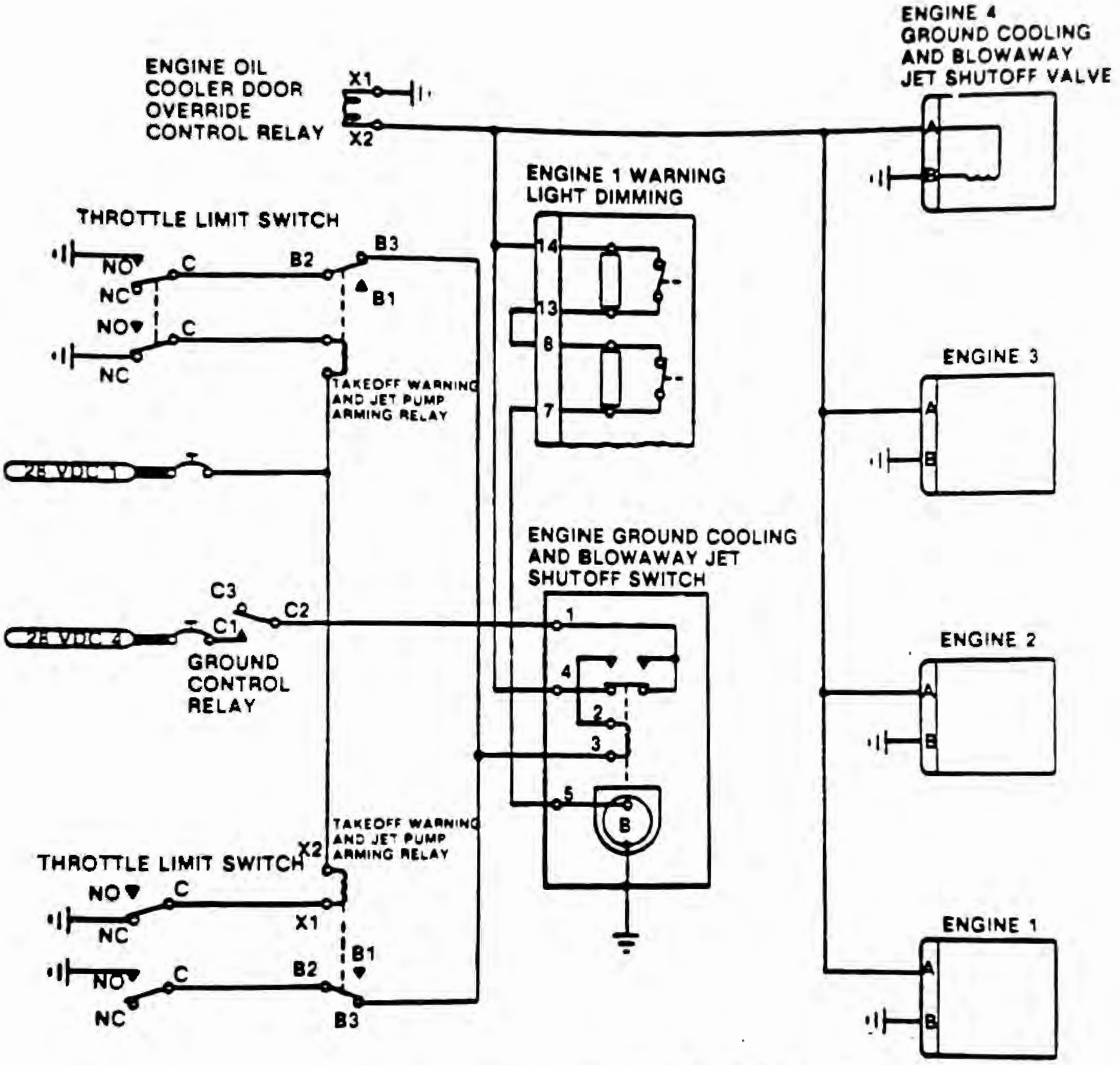
(2) Engine Ground Cooling and Blowaway Jet Shutoff Switch

(a) The engine ground cooling and blowaway jet shutoff switch provides common control for all engines. The switch, located on the flight engineer's panel, is used to manually control the operation of the jet shutoff valves. The switch has a blue translucent knob with an integral indicating light installed.

(b) A ground control relay connects power to the shutoff switch when the airplane is on the ground and disconnects power when the nose gear strut extends. When the knob is depressed, the holding coil of the switch is energized by the takeoff warning and jet pump arming relays, which, in turn, are operated by the throttle lever limit switches.

(c) When the shutoff switch is in the on (out) position, the light is on and the jet pump shutoff valves are open. The switch is spring loaded to the on position. When the switch is depressed, it is held in by a holding coil provided that throttle levers No. 1 and 2, No 3 and 4, or any combination of three or four throttles are advanced to actuate the throttle lever switches. When the switch is in the off position, the valves are closed and the light is off. In this condition the oil cooler air outlet door reverts to normal operation and the oil cooler door is no longer interlocked in the open position.

(d) The internal mechanism of the switch consists of a plunger with a shorting bar attached, which moves axially within a solenoid holding coil. In one position the plunger is spring loaded to close a pair of contacts with the shorting bar. When the plunger is depressed, the contacts are opened and a second pair of contacts is closed by the shorting bar. When the holding coil is energized, or the knob is depressed, the plunger remains in the depressed position with the second pair of contact closed, supplying power to the light.


ENGINE OIL COOLER DOOR OVERRIDE CONTROL RELAY
X1
X2
ENGINE 4 GROUND COOLING AND BLOWAWAY JET SHUTOFF VALVE
A
B
ENGINE 1 WARNING LIGHT DIMMING
14
13
8
7
THROTTLE LIMIT SWITCH
NO
C
NC
B2
B3
B1
TAKEOFF WARNING AND JET PUMP ARMING RELAY
28 VDC 1
ENGINE 3
ENGINE GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
C3
C2
C1
28 VDC 4
GROUND CONTROL RELAY
1
4
2
3
5
B
ENGINE 2
THROTTLE LIMIT SWITCH
X2
X1
ENGINE 1

JET PUMP INDICATING -- SCHEMATIC

FTX80407

Figure 71-16

duct. The four throttle lever actuated switches, located in the control pedestal, operate the takeoff warning and jet pump shutoff arming relays.

B. Operation

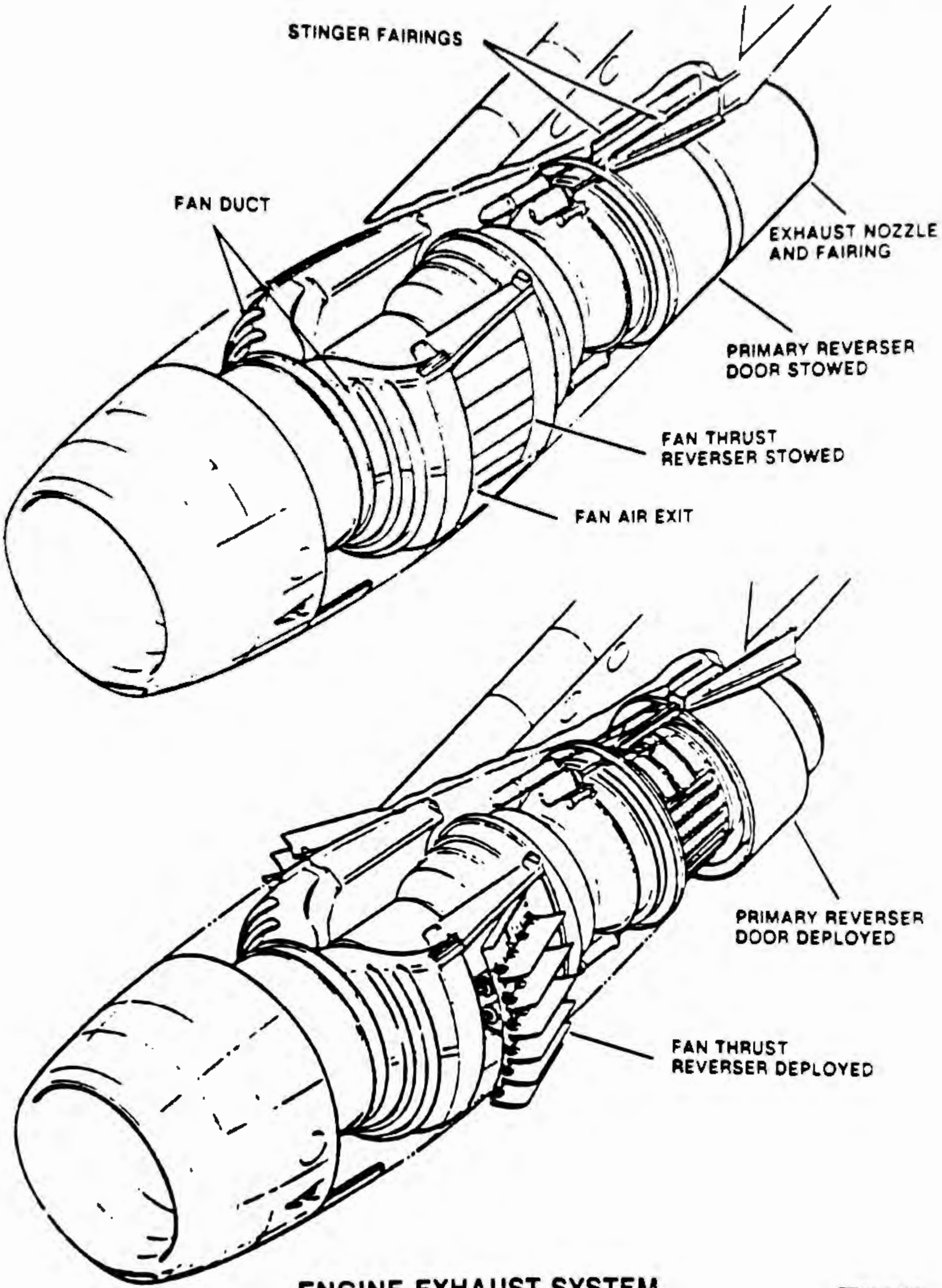
(1) Ground Cooling and Blowaway Jet Pump Indicating System

(a) The integral light in the engine ground cooling and blowaway jet shutoff switch comes on when the jet shutoff valves open. A ground control relay supplies power to the shutoff switch when the airplane is on the ground and disconnects power when the nose gear strut is extended. Depressing the shutoff switch (spring loaded in the out position) disconnects power from the shutoff valve. The valve closes, and the indicating light goes off. Releasing the shutoff switch knob allows the knob to return to the out (open) position, completing a circuit to the shutoff valves. The valves open, and the indicating light comes on. If throttle levers No. 1 and 2, No. 3 and 4, or any combination of three or four throttles are advanced to actuate the throttle lever switches when the shutoff switch is depressed, the holding coil of the switch is energized by the takeoff warning and jet pump arming relays and stays in the depressed position.

(b) During takeoff, the nose gear switch is actuated to the closed position when the nose gear strut is extended and the circuit to the shutoff valves and switch is broken. If the shutoff switch is in the on position (knob out, light on), the valves will close, and the indicating light will go off. If the shutoff switch is in the off position (knob in, light off), the switch returns to the on position (knob out), and the indicating light remains off.

(c) During landing, the nose gear switch is actuated to the open position completing a circuit to the shutoff valves and switch. The valves open, and the indicating light comes on.

-61 DIFFERENCES POWERPLANT


STINGER FAIRINGS
FAN DUCT
EXHAUST NOZZLE AND FAIRING
PRIMARY REVERSER DOOR STOWED
FAN THRUST REVERSER STOWED
FAN AIR EXIT
PRIMARY REVERSER DOOR DEPLOYED
FAN THRUST REVERSER DEPLOYED

ENGINE EXHAUST SYSTEM

FTX80408

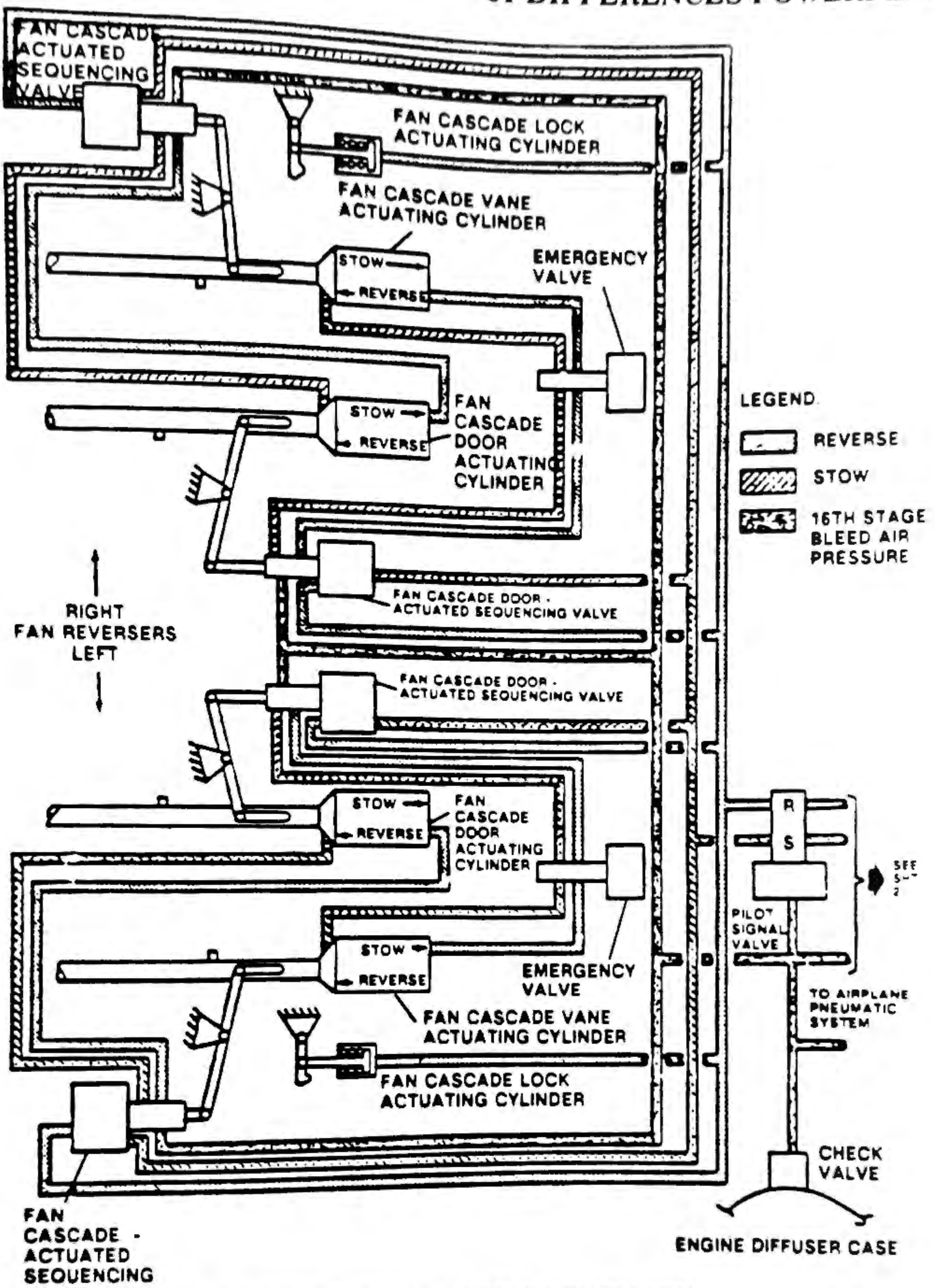
Figure 71-17

system contains a cascade vane assembly, a cascade vane support, six cascade doors, two cascade vane actuating cylinders, a cascade door actuating cylinder, two sequencing valves and an emergency valve.

(2) Both systems are controlled simultaneously through the movement of a thrust brake lever for each engine at the pilots control pedestal, cable-connected to the power drum on the engine. All four engines have identical thrust reverser systems, each controlled individually. Thrust reverser system power is provided by pneumatic pressure from the engine sixteenth stage compressor through a bleed in the engine diffuser case, and is controlled at the power drum by a pilot signal valve.

(3) An emergency thrust reverser retraction system provides both primary and fan thrust reverser retraction should a malfunction occur in the normal system.

-61 DIFFERENCES POWERPLANT


FAN CASCADE ACTUATED SEQUENCING VALVE
FAN CASCADE LOCK ACTUATING CYLINDER
FAN CASCADE VANE ACTUATING CYLINDER
STOW
REVERSE
EMERGENCY VALVE
STOW
REVERSE
FAN CASCADE DOOR ACTUATING CYLINDER
LEGEND
▭ REVERSE
▨ STOW
▩ 16TH STAGE BLEED AIR PRESSURE
FAN CASCADE DOOR - ACTUATED SEQUENCING VALVE
RIGHT
FAN REVERSERS
LEFT
FAN CASCADE DOOR - ACTUATED SEQUENCING VALVE
R
S
STOW
REVERSE
FAN CASCADE DOOR ACTUATING CYLINDER
SEE
PILOT SIGNAL VALVE
STOW
REVERSE
EMERGENCY VALVE
FAN CASCADE VANE ACTUATING CYLINDER
TO AIRPLANE PNEUMATIC SYSTEM
FAN CASCADE LOCK ACTUATING CYLINDER
CHECK VALVE
FAN CASCADE - ACTUATED SEQUENCING VALVE
ENGINE DIFFUSER CASE
FTX80410

THRUST REVERSER SYSTEM SCHEMATIC

Figure 71-19

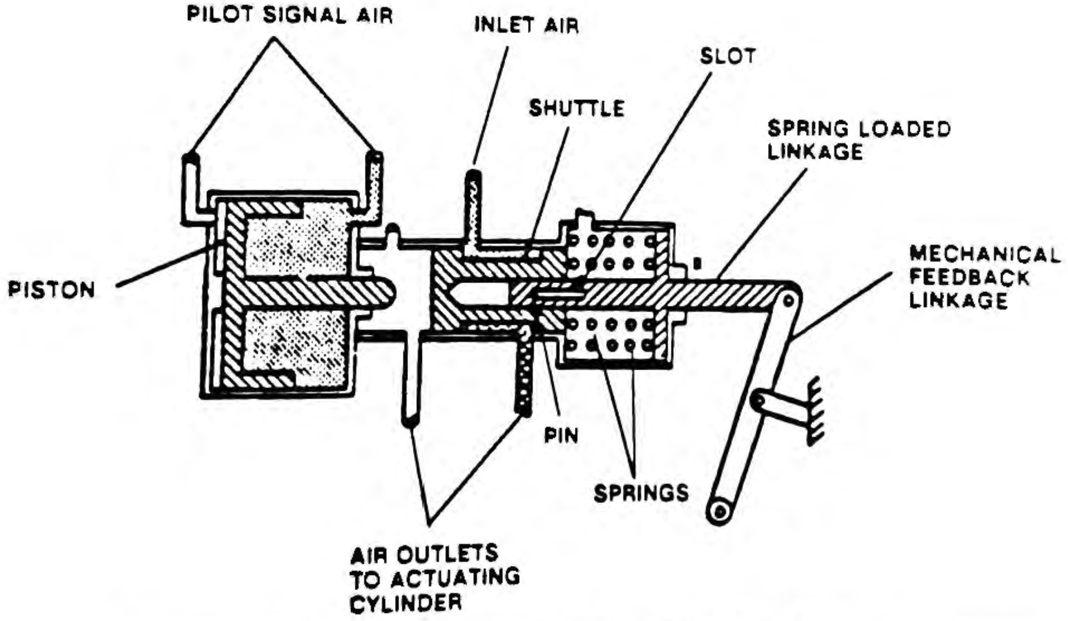
B. Operation

(1) Sequencing Valve Operation (See Figure 71-21)

(a) In order to understand the thrust reverser system operation it is first necessary to understand the operation and function of the sequencing valves. The function of each sequencing valve is to delay the operation of one actuating cylinder until another actuating cylinder has nearly completed its travel. The sequencing valves all operate similarly, so only one is discussed.

(b) The sequencing valve contains a shuttle which has two positions. In one position the shuttle ports air pressure to one end of an actuating cylinder, and in the other position, air is ported to the opposite end of the actuating cylinder.

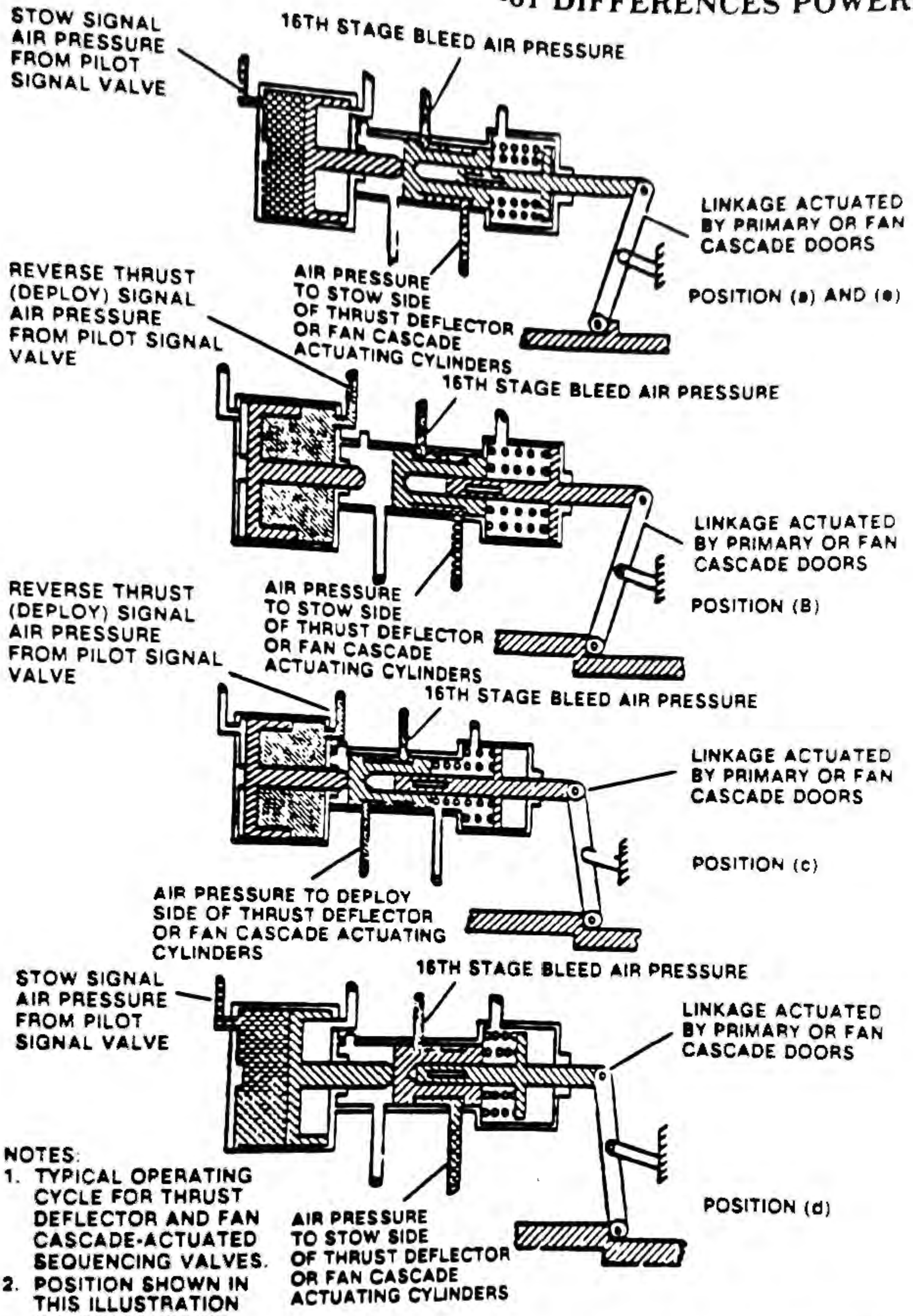
(c) The shuttle is acted upon by an air-operated piston at one end of the sequencing valve, and by a spring-loaded linkage at the other end of the sequencing valve. The air-operated piston is moved by a signal from the pilot valve. When signal air pressure forces the piston inward, the piston shaft bears against the shuttle, forcing



SEQUENCING VALVE -- SCHEMATIC DIAGRAM FTX80412

Figure 71-21

-61 DIFFERENCES POWERPLANT


STOW SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
LINKAGE ACTUATED BY PRIMARY OR FAN CASCADE DOORS
POSITION (a) AND (e)
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
AIR PRESSURE TO STOW SIDE OF THRUST DEFLECTOR OR FAN CASCADE ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE
LINKAGE ACTUATED BY PRIMARY OR FAN CASCADE DOORS
POSITION (B)
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
AIR PRESSURE TO STOW SIDE OF THRUST DEFLECTOR OR FAN CASCADE ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE
LINKAGE ACTUATED BY PRIMARY OR FAN CASCADE DOORS
POSITION (c)
AIR PRESSURE TO DEPLOY SIDE OF THRUST DEFLECTOR OR FAN CASCADE ACTUATING CYLINDERS
STOW SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
LINKAGE ACTUATED BY PRIMARY OR FAN CASCADE DOORS
POSITION (d)
AIR PRESSURE TO STOW SIDE OF THRUST DEFLECTOR OR FAN CASCADE ACTUATING CYLINDERS

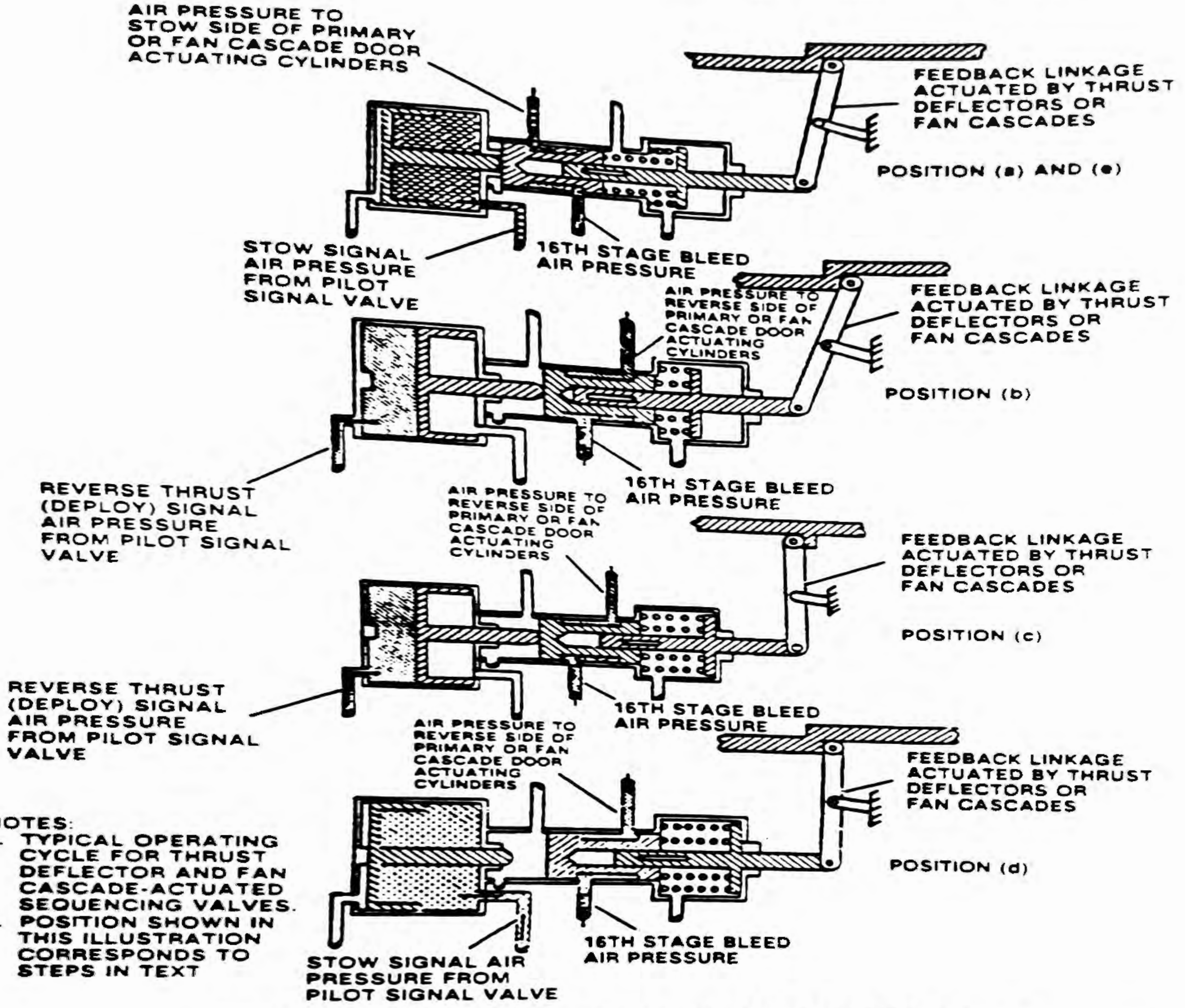
NOTES:
1. TYPICAL OPERATING CYCLE FOR THRUST DEFLECTOR AND FAN CASCADE-ACTUATED SEQUENCING VALVES.
2. POSITION SHOWN IN THIS ILLUSTRATION CORRESPONDS TO STEPS IN TEXT

FTX80413

TYPICAL SEQUENCING VALVE OPERATING CYCLE

Figure 71-22

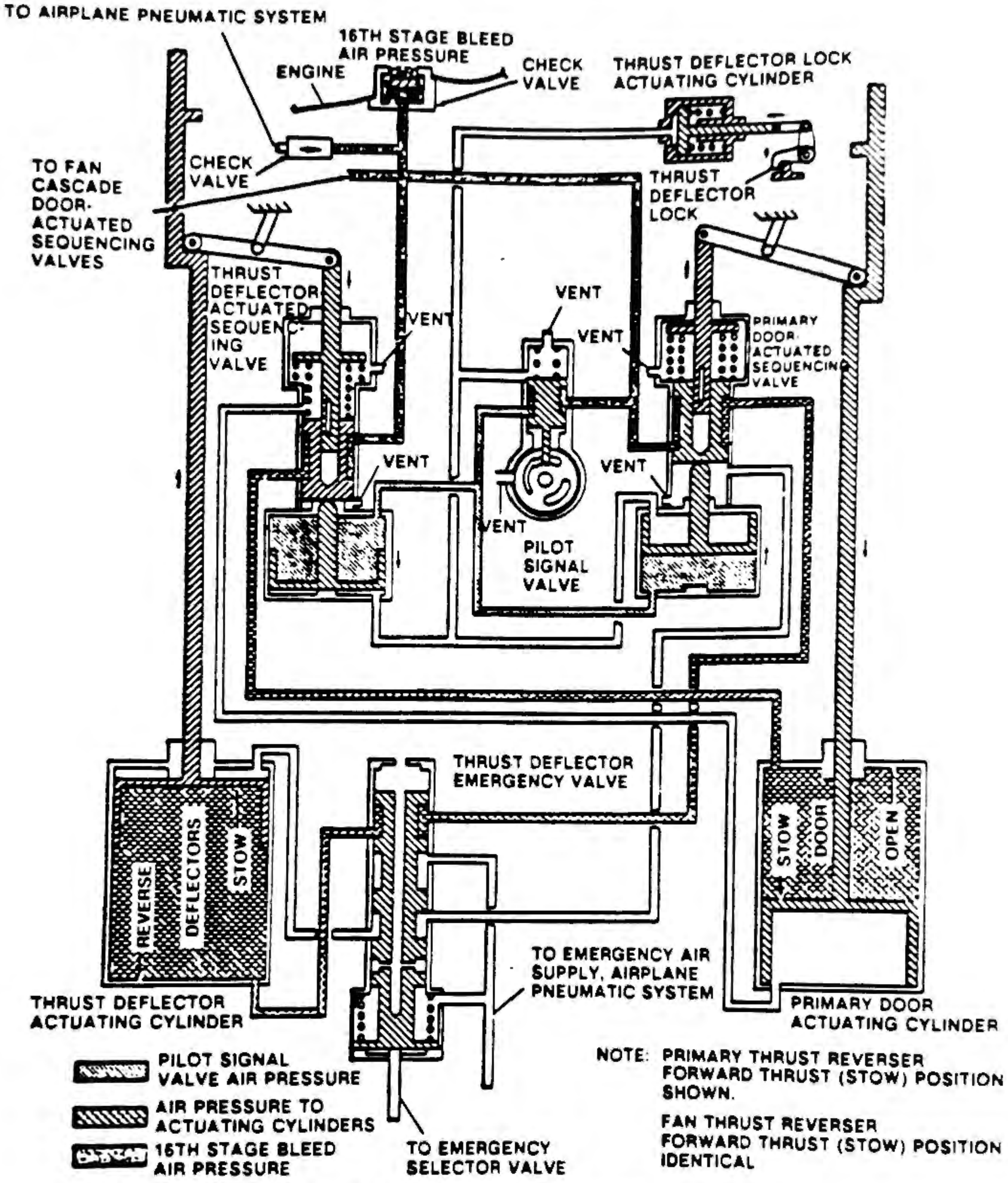
-61 DIFFERENCES POWERPLANT


AIR PRESSURE TO STOW SIDE OF PRIMARY OR FAN CASCADE DOOR ACTUATING CYLINDERS
FEEDBACK LINKAGE ACTUATED BY THRUST DEFLECTORS OR FAN CASCADES
POSITION (a) AND (e)
STOW SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
AIR PRESSURE TO REVERSE SIDE OF PRIMARY OR FAN CASCADE DOOR ACTUATING CYLINDERS
FEEDBACK LINKAGE ACTUATED BY THRUST DEFLECTORS OR FAN CASCADES
POSITION (b)
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
AIR PRESSURE TO REVERSE SIDE OF PRIMARY OR FAN CASCADE DOOR ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE
FEEDBACK LINKAGE ACTUATED BY THRUST DEFLECTORS OR FAN CASCADES
POSITION (c)
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
AIR PRESSURE TO REVERSE SIDE OF PRIMARY OR FAN CASCADE DOOR ACTUATING CYLINDERS
FEEDBACK LINKAGE ACTUATED BY THRUST DEFLECTORS OR FAN CASCADES
POSITION (d)
STOW SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE

NOTES:
1. TYPICAL OPERATING CYCLE FOR THRUST DEFLECTOR AND FAN CASCADE-ACTUATED SEQUENCING VALVES.
2. POSITION SHOWN IN THIS ILLUSTRATION CORRESPONDS TO STEPS IN TEXT

TYPICAL SEQUENCING VALVE OPERATING CYCLE FTX80414

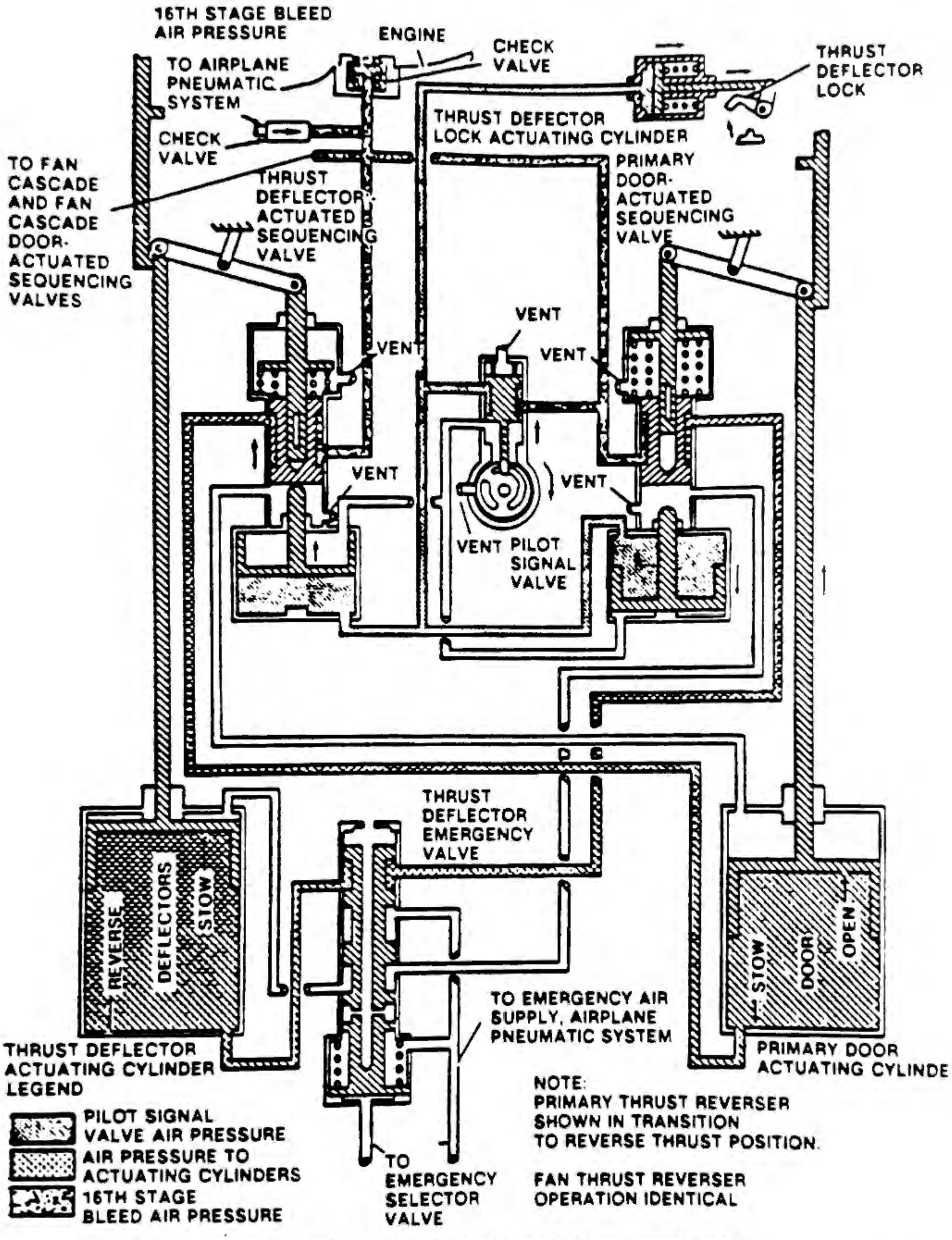
Figure 71-23


TO AIRPLANE PNEUMATIC SYSTEM
16TH STAGE BLEED AIR PRESSURE
ENGINE
CHECK VALVE
THRUST DEFLECTOR LOCK ACTUATING CYLINDER
TO FAN CASCADE DOOR-ACTUATED SEQUENCING VALVES
CHECK VALVE
THRUST DEFLECTOR LOCK
THRUST DEFLECTOR ACTUATED SEQUENCING VALVE
VENT
VENT
VENT
PRIMARY DOOR-ACTUATED SEQUENCING VALVE
VENT
VENT
VENT
PILOT SIGNAL VALVE
THRUST DEFLECTOR EMERGENCY VALVE
REVERSE
DEFLECTORS
STOW
STOW
DOOR
OPEN
TO EMERGENCY AIR SUPPLY, AIRPLANE PNEUMATIC SYSTEM
THRUST DEFLECTOR ACTUATING CYLINDER
PRIMARY DOOR ACTUATING CYLINDER
NOTE: PRIMARY THRUST REVERSER FORWARD THRUST (STOW) POSITION SHOWN.
FAN THRUST REVERSER FORWARD THRUST (STOW) POSITION IDENTICAL
PILOT SIGNAL VALVE AIR PRESSURE
AIR PRESSURE TO ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE
TO EMERGENCY SELECTOR VALVE

THRUST REVERSER SYSTEM OPERATION FTX80415

Figure 71-24

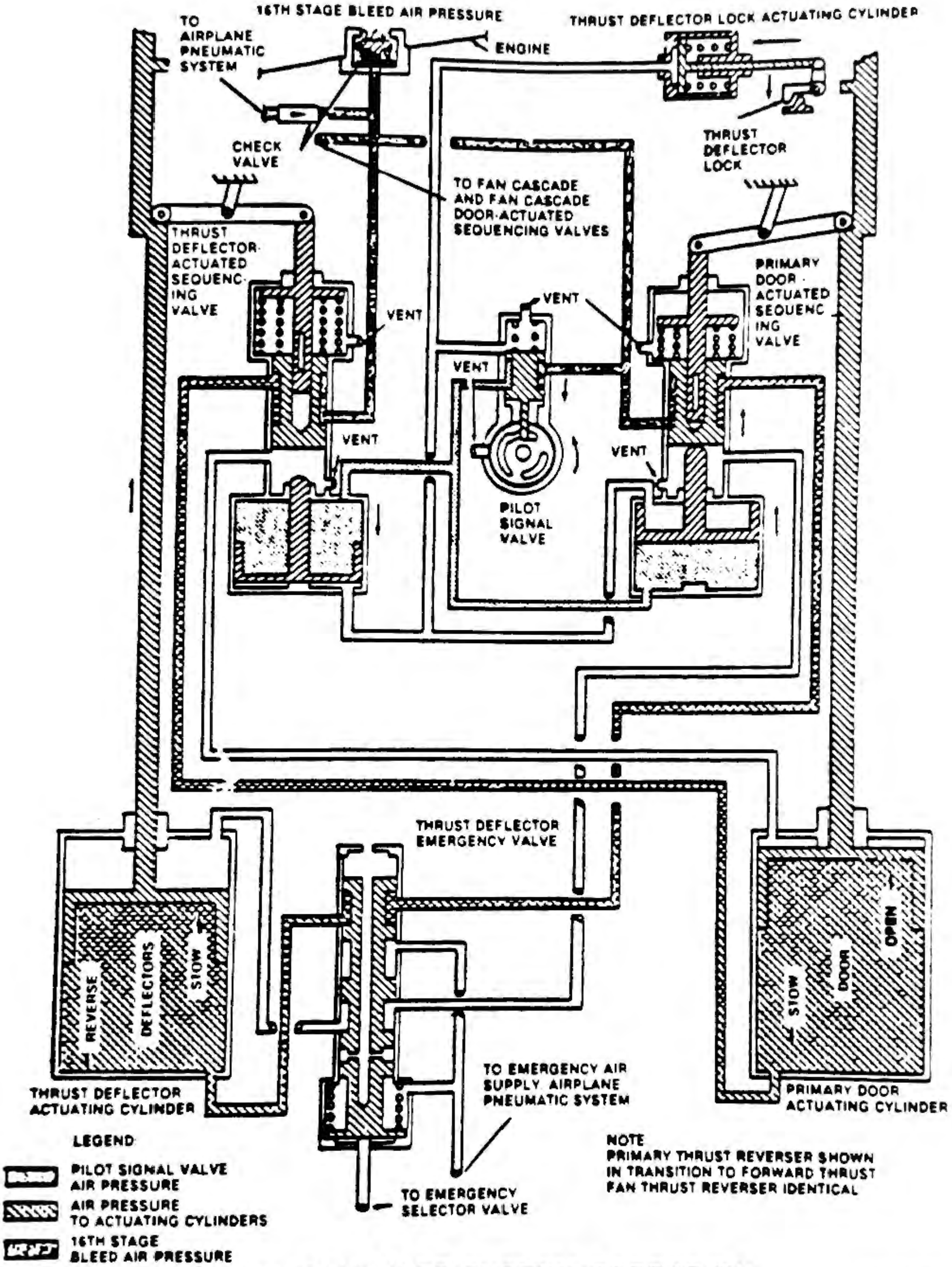
-61 DIFFERENCES POWERPLANT


16TH STAGE BLEED AIR PRESSURE
ENGINE
CHECK VALVE
TO AIRPLANE PNEUMATIC SYSTEM
THRUST DEFLECTOR LOCK
CHECK VALVE
THRUST DEFECTOR LOCK ACTUATING CYLINDER
TO FAN CASCADE AND FAN CASCADE DOOR-ACTUATED SEQUENCING VALVES
THRUST DEFLECTOR-ACTUATED SEQUENCING VALVE
PRIMARY DOOR-ACTUATED SEQUENCING VALVE
VENT
VENT
VENT
VENT
VENT
VENT
PILOT SIGNAL VALVE
D
E
THRUST DEFLECTOR EMERGENCY VALVE
REVERSE
DEFLECTORS
STOW
STOW
DOOR
OPEN
TO EMERGENCY AIR SUPPLY, AIRPLANE PNEUMATIC SYSTEM
THRUST DEFLECTOR ACTUATING CYLINDER
PRIMARY DOOR ACTUATING CYLINDE
TO EMERGENCY SELECTOR VALVE
LEGEND
PILOT SIGNAL VALVE AIR PRESSURE
AIR PRESSURE TO ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE
FTX80416

NOTE:
PRIMARY THRUST REVERSER SHOWN IN TRANSITION TO REVERSE THRUST POSITION.

FAN THRUST REVERSER OPERATION IDENTICAL

THRUST REVERSER SYSTEM OPERATION
Figure 71-25


16TH STAGE BLEED AIR PRESSURE
TO AIRPLANE PNEUMATIC SYSTEM
ENGINE
THRUST DEFLECTOR LOCK ACTUATING CYLINDER
CHECK VALVE
TO FAN CASCADE AND FAN CASCADE DOOR-ACTUATED SEQUENCING VALVES
THRUST DEFLECTOR LOCK
THRUST DEFLECTOR-ACTUATED SEQUENCING VALVE
VENT
VENT
PRIMARY DOOR-ACTUATED SEQUENCING VALVE
VENT
VENT
VENT
PILOT SIGNAL VALVE
THRUST DEFLECTOR EMERGENCY VALVE
REVERSE
DEFLECTORS
SLOW
SLOW
DOOR
OPEN
THRUST DEFLECTOR ACTUATING CYLINDER
PRIMARY DOOR ACTUATING CYLINDER
TO EMERGENCY AIR SUPPLY AIRPLANE PNEUMATIC SYSTEM
TO EMERGENCY SELECTOR VALVE
LEGEND
PILOT SIGNAL VALVE AIR PRESSURE
AIR PRESSURE TO ACTUATING CYLINDERS
16TH STAGE BLEED AIR PRESSURE

NOTE
PRIMARY THRUST REVERSER SHOWN IN TRANSITION TO FORWARD THRUST FAN THRUST REVERSER IDENTICAL

THRUST REVERSER SYSTEM OPERATION

FTX80418

Figure 71-27

2 Emergency operation is initiated by positioning the thrust brake emergency retraction switch on the forward overhead switch panel to the retract position. Twenty-eight-volts DC is routed through the closed contacts of the switch from the E.P.C. circuit breaker panel to the emergency selector valve, which actuates the solenoid, routing air from the airplane pneumatic system to the primary and fan cascade emergency valves. The emergency valves then port pressurized air to the stow side of the thrust deflector and fan cascade actuating cylinders.

16. Primary Thrust Reverser System - Description and Operation

A. General (See Figure 71-29)

(1) The primary thrust reverser system is contained in a cylindrical structure installed between the aft face of the engine turbine and exhaust flange and the engine exhaust nozzle. It consists of a primary reverser case containing two deflectors which pivot on a vertical axis from a stowed position in the sides of the reverser case and meet on the vertical centerline to block the flow of exhaust gases from the engine. The deflected gases exit through cascade vanes installed on either side of the reverser case. A primary door assembly encompasses the reverser case, and is mounted on two tracks which permit the door to slide aft during reverse thrust operation, exposing the cascade vanes and allowing the exhaust gases to escape. When forward thrust is selected, the deflectors pivot to the stowed position and the door assembly slides forward, completely covering the cascade vanes presenting a smooth aerodynamic surface.

B. Component Description

(1) Thrust Deflectors (See Figure 71-30)

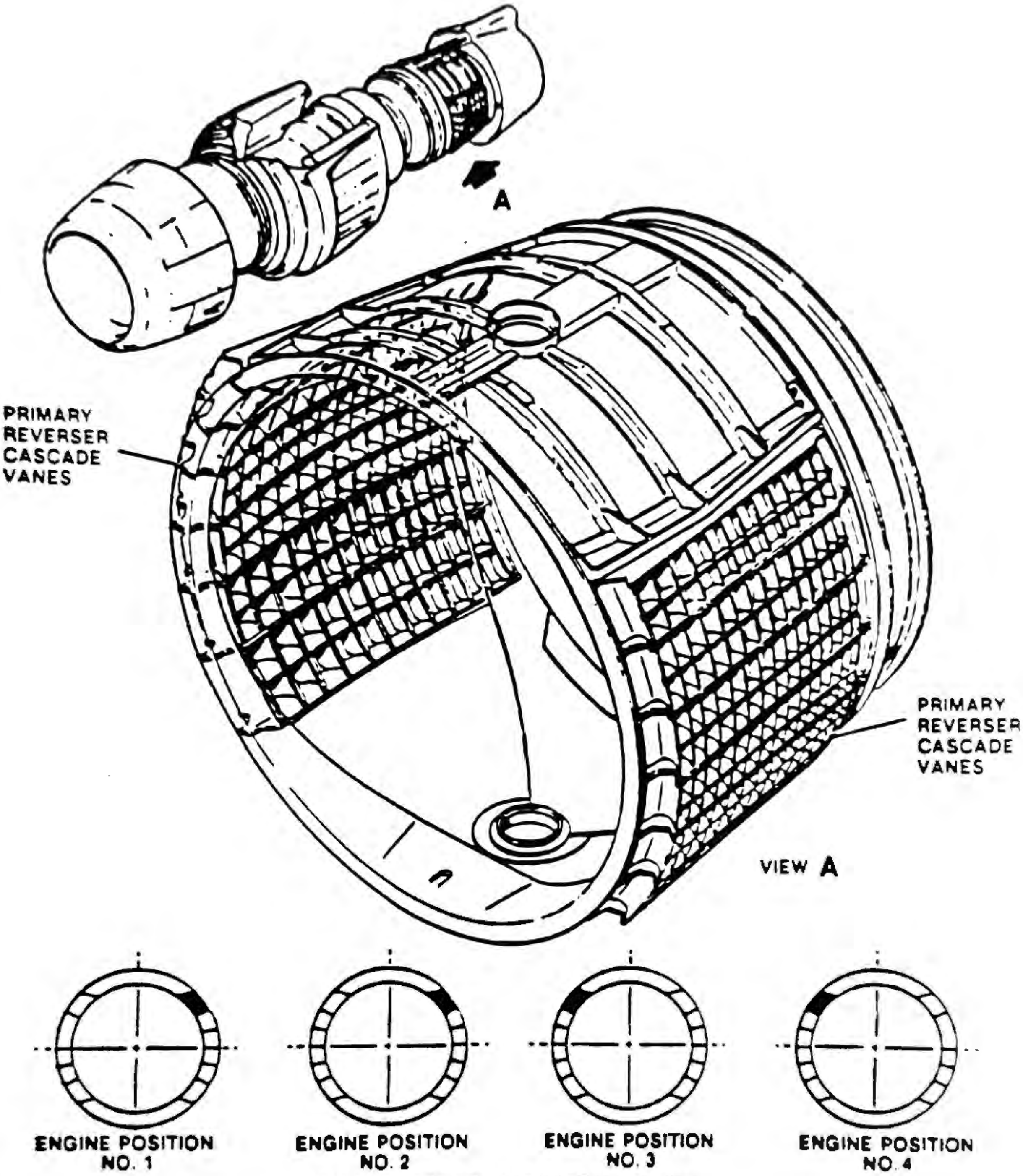
(a) The thrust deflectors are semi-hemispherically shaped and are mounted on a common vertical axis near the center of the reverser case. When in the stowed position, each deflector fairs closely with the concave inner surface of the cascade vanes to present a minimum interference to exhaust gas flow. When deployed to the reverse thrust position the mating edges of the deflectors form a seal with each other. The outer edges of the deflectors form a seal with the reverser case inner surface, thus effectively blocking the flow of exhaust gas.

(2) Cascade Vanes (See Figure 71-31)

(a) Cascade vane assemblies are employed on each side of the primary thrust reverser case to permit the blocked exhaust gases to escape, after being diverted to a forward direction. Six cascade vane assemblies are installed in an opening on one side of the reverser case. Five cascade vane assemblies and one dummy cascade vane assembly are installed in an opening on the other side of the reverser case. The dummy vane is positioned on the upper right side of No. 1 and No. 2 engines, and on the upper left side of No. 3 and No. 4 engines. Each cascade vane assembly contains a series of sixteen airfoils set at a carefully determined angle to provide the most efficient reversal of thrust. The angle of deflection varies with each set of vanes.

(3) Primary Door (See Figure 71-32)

(a) The primary door is cylindrical and covers the outer periphery of the reverser case. Two tracks, one on the upper surface of the reverser case and the other mounted on the bottom surface, support and guide the primary door in its fore and aft travel. The cascade vanes are fully exposed when the door is moved to the extreme aft position. When in the forward position, the door fairs with the nacelle structure at the forward end, and with the exhaust nozzle fairing at the aft end.



PRIMARY REVERSER CASCADE VANES FTX80422

Figure 71-31

17. Fan Thrust Reverser System - Description and Operation

A. General (See Figure 71-33)

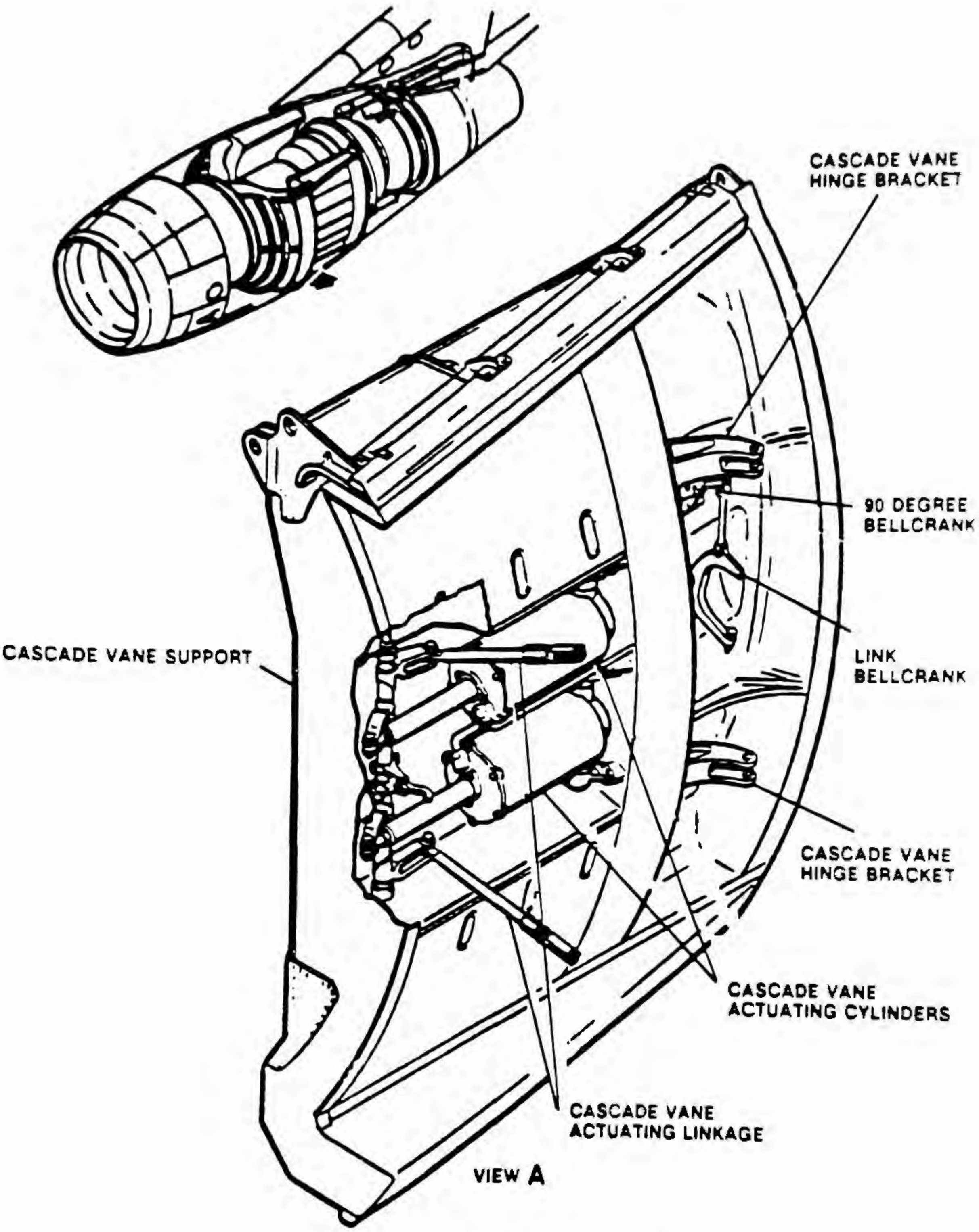
(1) The fan thrust reverser system is divided into two sections identical in operation. One section reverses the discharge from the left fan discharge duct and the other section reverses the discharge from the right fan duct. The system are installed aft of the fan discharge ducts and each consists of a cascade vane support and a cascade vane assembly. The cascade vane assembly is hinged at the aft end and contains vanes which are positioned to change the direction of air flow. Six hinged doors cover the cascade vane assembly vanes when the cascade vane assembly is in the stowed position. The doors open to permit air to pass through the cascade vanes when the assembly is in the reverse thrust (deployed) position. The cascade vane support assembly is hinged at the upper side to permit access to engine-mounted components.

B. Component Description

(1) Fan Cascade Vane Support and Cascade Vane Assembly (See Figure 71-34)

(a) The cascade vane support is designed to fit the curvature of the engine at the fan discharge duct. It is held in position by struts which are attached to the engine. The fan cascade vane support may be disconnected at the bottom and swung upward for access to engine-mounted components.

(b) A cascade vane assembly is installed at the outboard side of each cascade vane support. The cascade vane assembly consists of a frame which holds six cascade vanes. Each cascade vane contains twenty airfoil sections whose function is to divert the direction of air flow. The cascade vane assembly is hinged at the aft end.

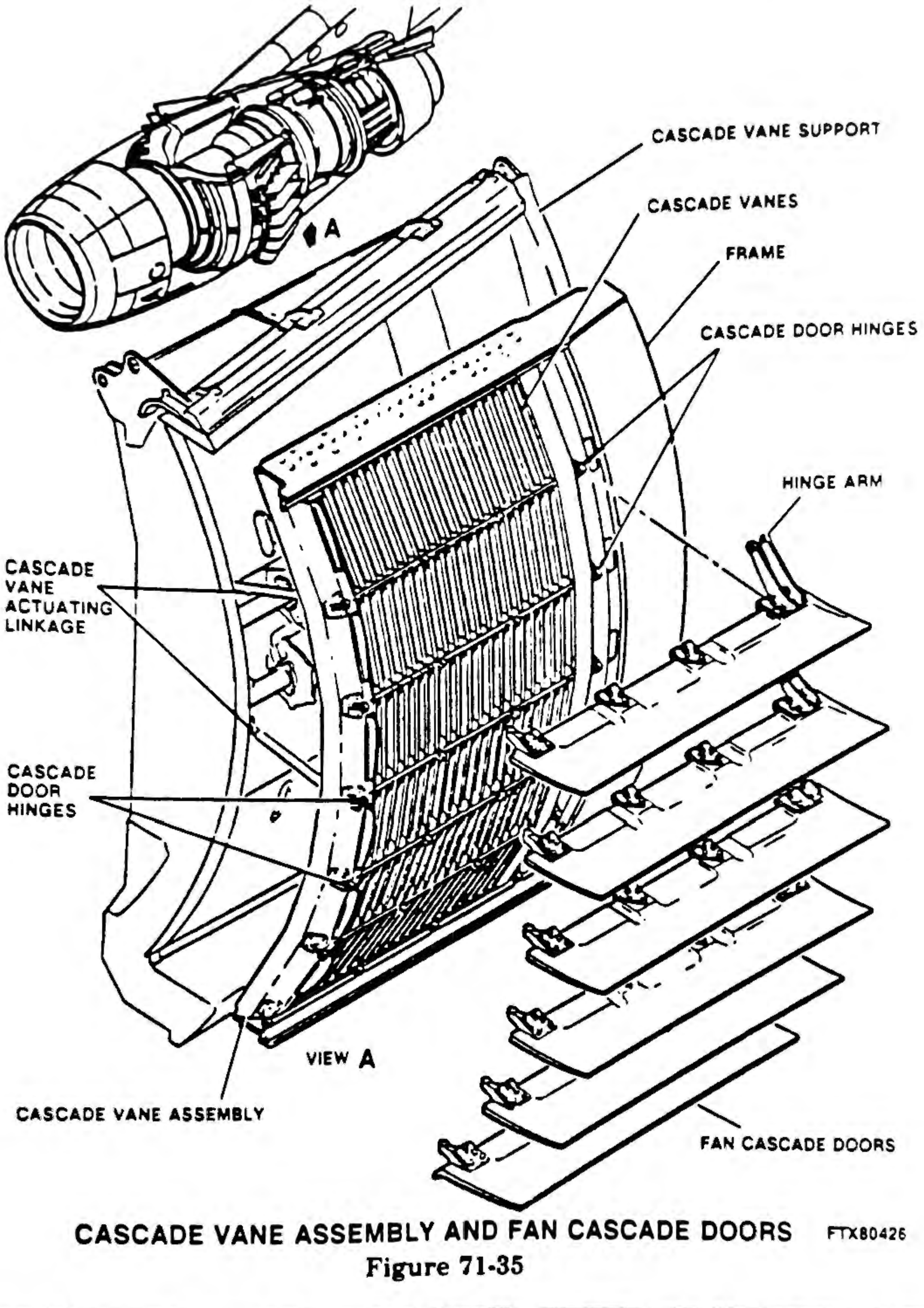

CASCADE VANE HINGE BRACKET
90 DEGREE BELLCRANK
CASCADE VANE SUPPORT
LINK BELLCRANK
CASCADE VANE HINGE BRACKET
CASCADE VANE ACTUATING CYLINDERS
CASCADE VANE ACTUATING LINKAGE
VIEW A

FAN CASCADE SUPPORT

FTX80425

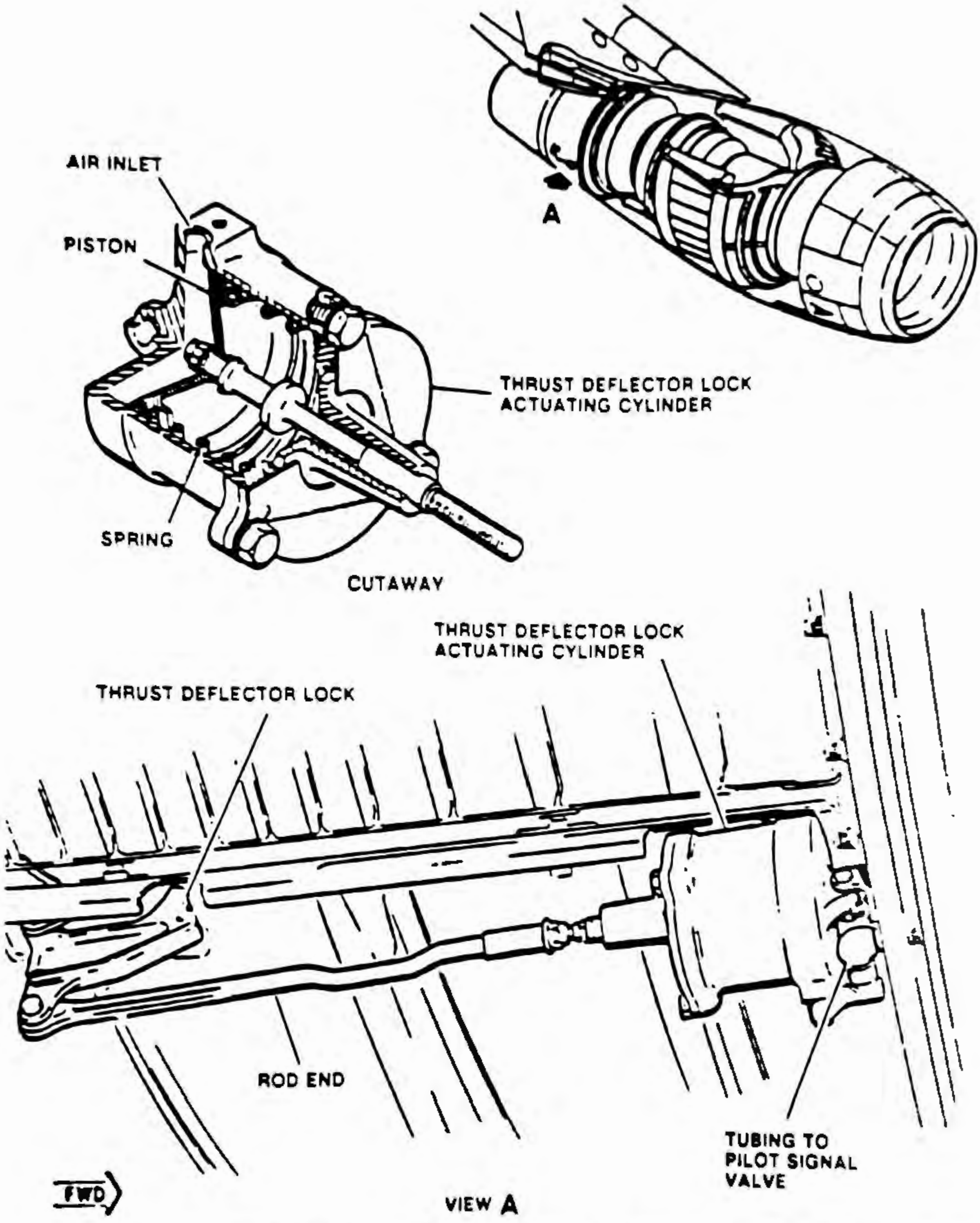
Figure 71-34

-61 DIFFERENCES POWERPLANT



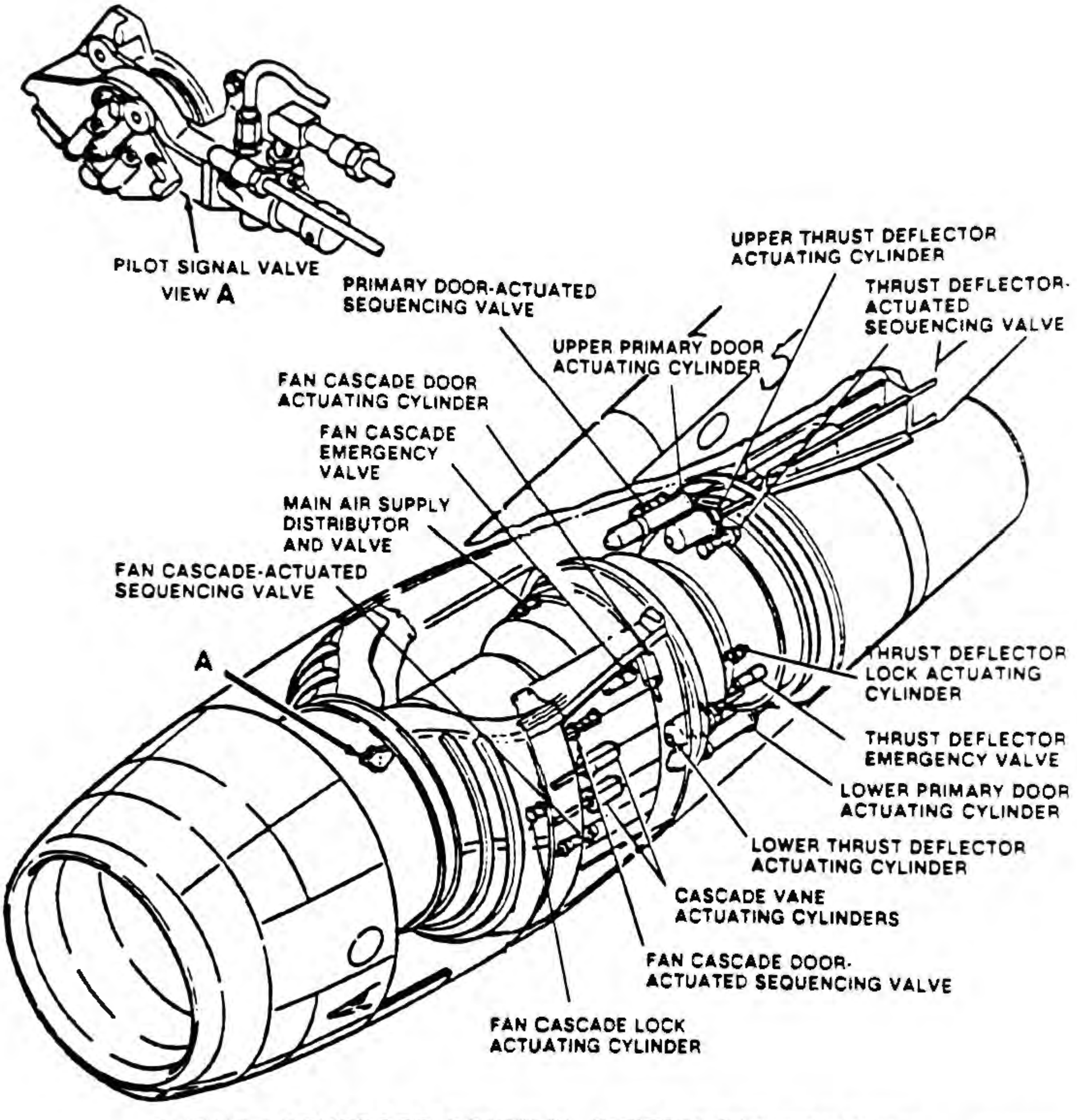
CASCADE VANE ASSEMBLY AND FAN CASCADE DOORS FTX80426
Figure 71-35

-61 DIFFERENCES POWERPLANT


A
AIR INLET
PISTON
THRUST DEFLECTOR LOCK ACTUATING CYLINDER
SPRING
CUTAWAY
THRUST DEFLECTOR LOCK ACTUATING CYLINDER
THRUST DEFLECTOR LOCK
ROD END
TUBING TO PILOT SIGNAL VALVE
FWD
VIEW A

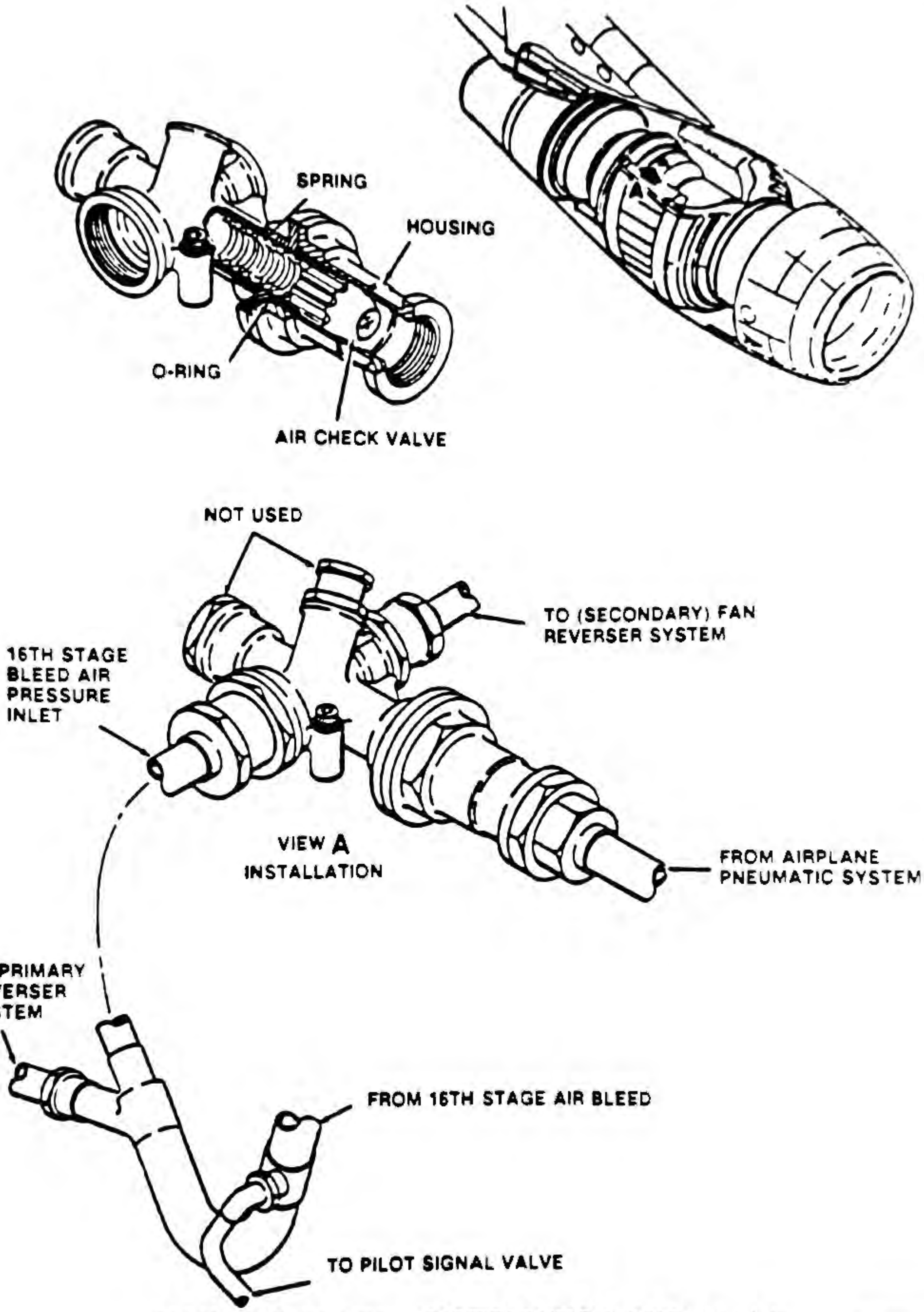
THRUST DEFLECTOR LOCK ACTUATING CYLINDER FTX80435

Figure 71-44


PILOT SIGNAL VALVE
VIEW A
PRIMARY DOOR-ACTUATED SEQUENCING VALVE
UPPER THRUST DEFLECTOR ACTUATING CYLINDER
THRUST DEFLECTOR-ACTUATED SEQUENCING VALVE
UPPER PRIMARY DOOR ACTUATING CYLINDER
FAN CASCADE DOOR ACTUATING CYLINDER
FAN CASCADE EMERGENCY VALVE
MAIN AIR SUPPLY DISTRIBUTOR AND VALVE
FAN CASCADE-ACTUATED SEQUENCING VALVE
A
THRUST DEFLECTOR LOCK ACTUATING CYLINDER
THRUST DEFLECTOR EMERGENCY VALVE
LOWER PRIMARY DOOR ACTUATING CYLINDER
LOWER THRUST DEFLECTOR ACTUATING CYLINDER
CASCADE VANE ACTUATING CYLINDERS
FAN CASCADE DOOR-ACTUATED SEQUENCING VALVE
FAN CASCADE LOCK ACTUATING CYLINDER

THRUST REVERSER CONTROL SYSTEM COMPONENTS FTX80426

Figure 71-37


SPRING
HOUSING
O-RING
AIR CHECK VALVE
NOT USED
TO (SECONDARY) FAN REVERSER SYSTEM
16TH STAGE BLEED AIR PRESSURE INLET
VIEW A INSTALLATION
FROM AIRPLANE PNEUMATIC SYSTEM
TO PRIMARY REVERSER SYSTEM
FROM 16TH STAGE AIR BLEED
TO PILOT SIGNAL VALVE

MAIN AIR SUPPLY DISTRIBUTOR AND VALVE FTX80429

Figure 71-38

(3) Thrust Deflector Actuating Cylinder (See Figures 71-40 & 71-41)

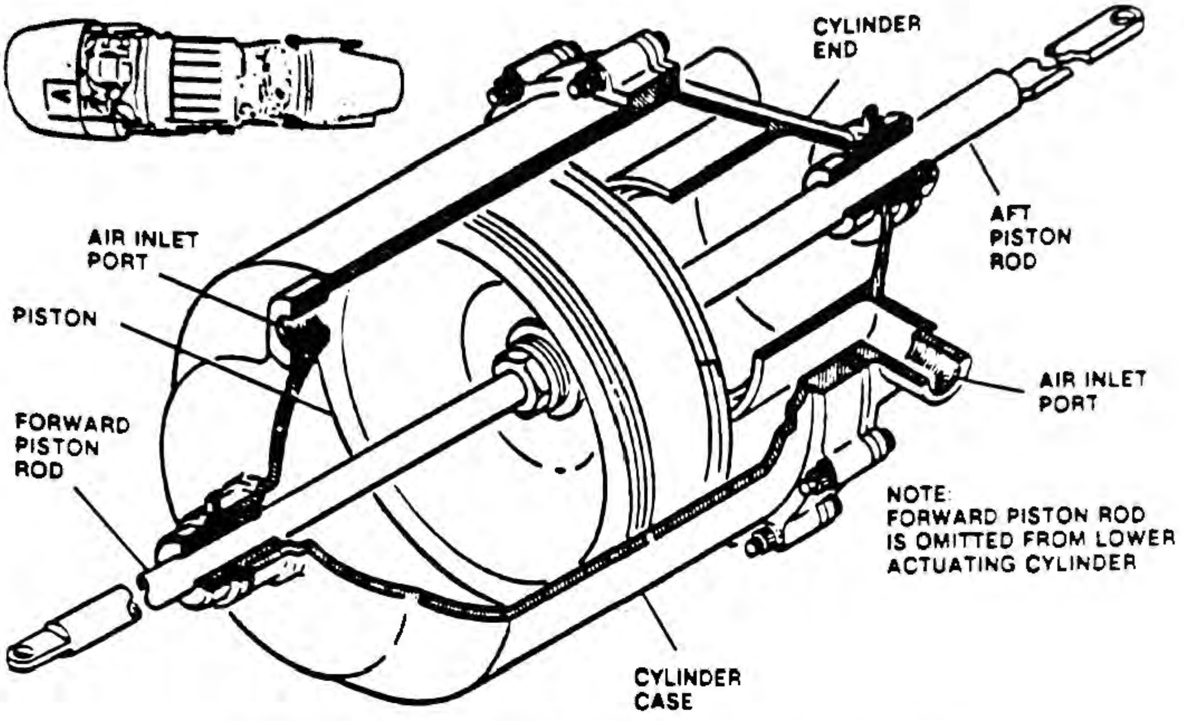
(a) Two thrust deflector actuating cylinders are used to operate the thrust reverser deflectors. They are mounted on brackets extending between the front and rear flanges at the 12 and 6 o'clock positions on the turbine nozzle case. The cylinders are double-acting, with supply air for closing the deflectors entering the forward side of the cylinder, and supply air for deploying the deflectors entering the cylinder rear connection. The piston rod extends from the aft end of the cylinder and is attached to the deflector actuating mechanism. The top cylinder incorporates a second rod which extends from the forward end of the cylinder and is connected to the thrust deflector-actuated sequencing valve by a mechanical linkage.

(4) Primary Door Actuating Cylinder (See Figure 71-41)

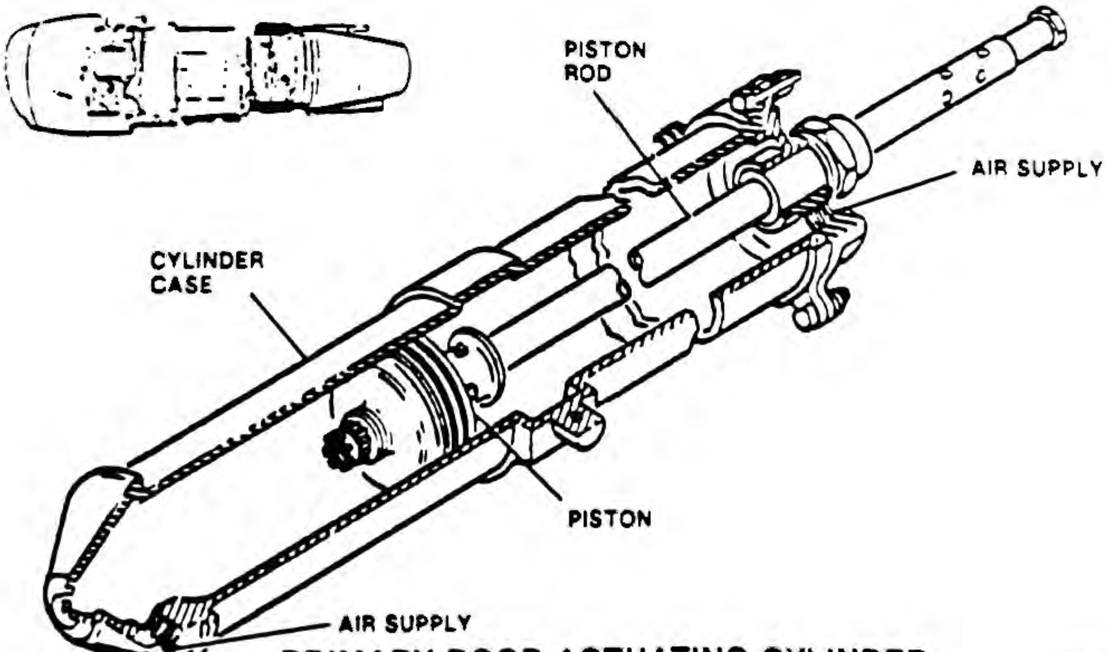
(a) The primary door is operated by two identical actuating cylinders, operating simultaneously. One cylinder is located adjacent to the upper thrust deflector actuating cylinder, and the other is located adjacent to the lower thrust deflector actuating cylinder, as described above. Each cylinder piston rod extends rearward and attaches to a bracket on the inner surface of the primary door. Supply air enters each cylinder at the front connection for door opening and at the rear connection for door closing.

(5) Emergency Selector Valve (See Figure 71-42)

(a) An emergency selector valve is mounted at the 12 o'clock position on the engine diffuser case near the rear flange. The selector valve is solenoid operated and distributes aiplane pneumatic system emergency signal air and supply air to the primary and fan emergency valves.



THRUST DEFLECTOR ACTUATING CYLINDER



PRIMARY DOOR ACTUATING CYLINDER

FTX80432

Figure 71-41

(6) Thrust Deflector Emergency Valve (See Figure 71-43)

(a) The thrust deflector emergency valve is located on the lower left quadrant of the engine turbine section. The valve contains a spring-loaded shuttle which receives signal air pressure from the emergency selector valve and directs air pressure to the stow side of the thrust deflector actuating cylinders. Supply air for normal thrust deflector actuating cylinder operation passes through the thrust deflector emergency valve.

(7) Thrust Deflector Lock Actuating Cylinder (See Figure 71-44)

(a) A lock is provided at the thrust deflector to preclude inadvertent deployment of the deflectors during forward thrust operation. The lock consists of a cylinder and spring-loaded piston. The lock is located on the lower right side of the turbine nozzle case and is spring-loaded in the latched position. When thrust deflection deployment (reverse thrust) is selected, signal air pressure from the pilot signal valve forces the piston of the lock inward against the spring, releasing the latch.

(8) Fan Cascade Vane Actuating Cylinders (See Figure 71-45)

(a) Two cascade vane actuating cylinders are used to operate each cascade vane assembly. The two cylinders operate in unison and are mounted in a well in the cascade vane support. They are hinged at the aft end, and attached at the forward end to linkage which pivots the cascade vane assembly to the deployed and stowed positions. Each cylinder is double-acting, with close supply air pressure ported to the aft side of the piston, and open supply air pressure ported to the forward side of the piston. However, both open and close supply air is received at the aft end of the cylinder at a hinged fitting. Close supply air is directed to the aft side of the piston. Open supply air is conducted to the other end of the cylinder by means of a trunnion tube. This arrangement permits the cylinders to pivot at the aft attachment point.

(9) Fan Cascade Door Actuating Cylinder (See Figure 71-46)

(a) A fan cascade door actuating cylinder is installed in a vertical position at the aft end of each cascade vane support. The cylinder pivots at the upper attachment point. The piston rod is attached to a linkage mechanism which operates the cascade doors. Open and close supply air pressure is ported to a pivoting connection at the upper end of the cylinder. Open supply air is admitted directly into the cylinder and close supply air is routed to the piston rod end of the cylinder by means of a trunnion tube.

(10) Fan Emergency Valve

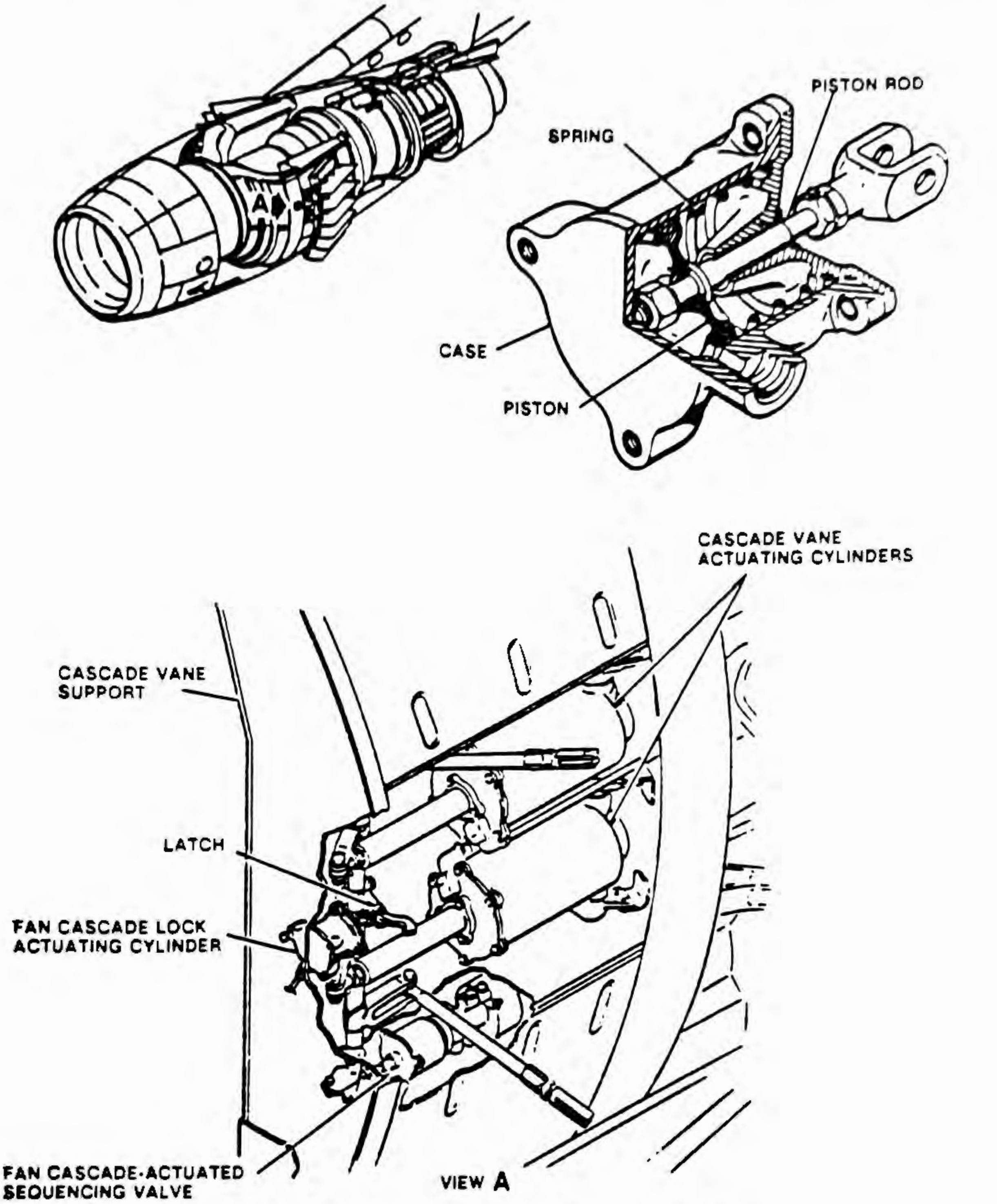
(a) A fan emergency valve is installed on the inner side of each cascade support. The emergency valve is installed on the upper section of the left cascade vane support and on the lower section of the right cascade vane support. The valve contains a spring-loaded shuttle which receives signal air pressure from the emergency selector valve to direct air pressure to the stow side of the fan cascade vane actuating cylinder. Supply air to fan cascade vane actuating cylinders is routed through the emergency valve.

(11) Fan Cascade Lock Actuating Cylinder (See Figure 71-47)

(a) A cascade lock actuating cylinder is installed at the forward end of vane assembly to preclude inadvertent deployment of the fan cascade vanes during forward thrust operations. The lock is located at the linkage shaft in each cascade vane support and is spring-loaded to the latched position. When cascade vane deployment is selected, signal air pressure from the pilot signal valve forces the piston of the lock inward against the spring, releasing the latch.

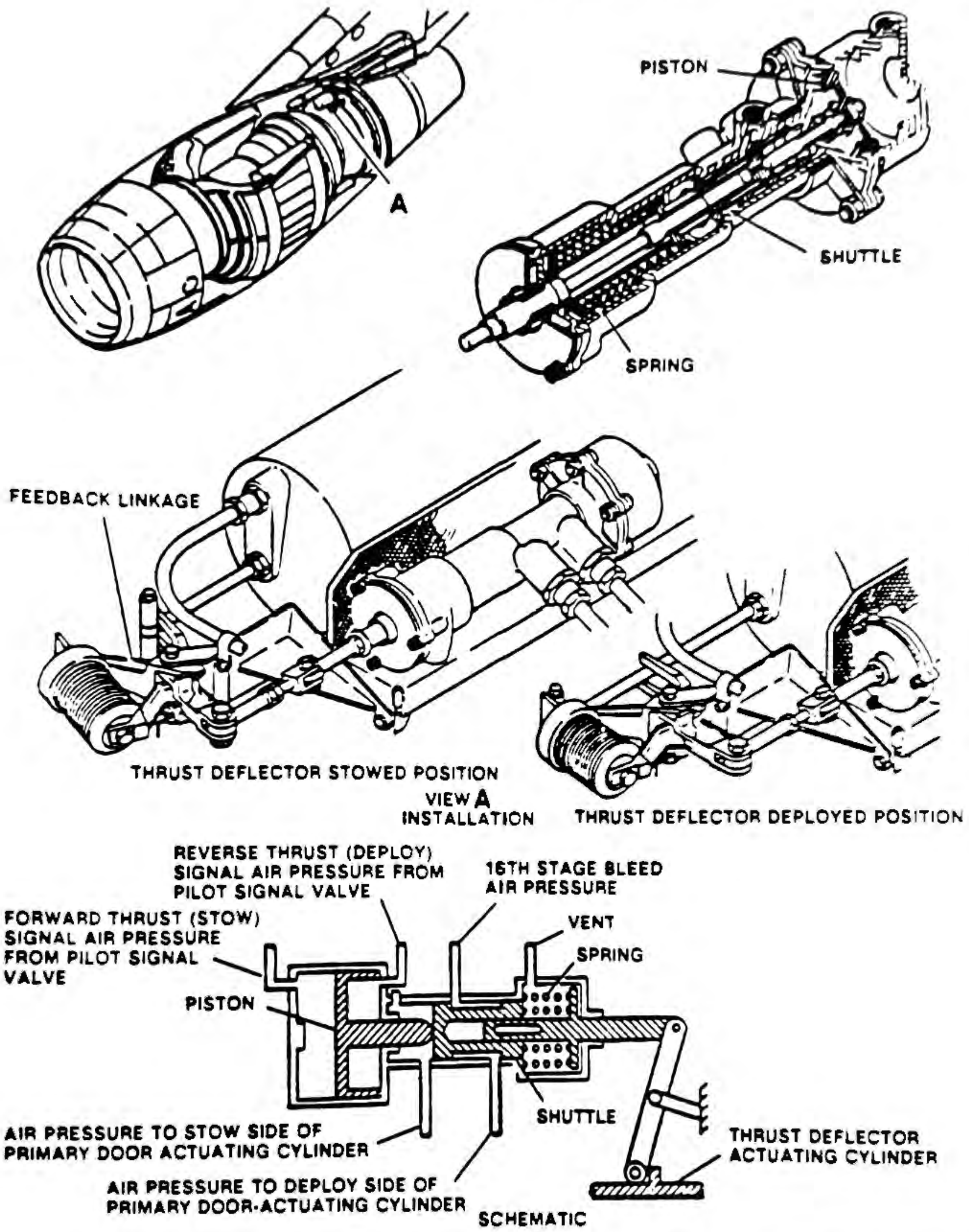
(12) Sequencing Valves

(a) Six sequencing valves are used throughout the thrust reverser control system to provide proper sequencing of the doors, cascade vanes, and thrust deflector actuating cylinders. The sequencing valves are as follows:


A
PISTON ROD
SPRING
CASE
PISTON
CASCADE VANE ACTUATING CYLINDERS
CASCADE VANE SUPPORT
LATCH
FAN CASCADE LOCK ACTUATING CYLINDER
FAN CASCADE-ACTUATED SEQUENCING VALVE
VIEW A

FAN CASCADE LOCK ACTUATING CYLINDER FTX80438

Figure 71-47


A
PISTON
SHUTTLE
SPRING
FEEDBACK LINKAGE
THRUST DEFLECTOR STOWED POSITION
VIEW A
INSTALLATION
THRUST DEFLECTOR DEPLOYED POSITION
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
FORWARD THRUST (STOW) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
VENT
SPRING
PISTON
SHUTTLE
AIR PRESSURE TO STOW SIDE OF PRIMARY DOOR ACTUATING CYLINDER
AIR PRESSURE TO DEPLOY SIDE OF PRIMARY DOOR-ACTUATING CYLINDER
THRUST DEFLECTOR ACTUATING CYLINDER
SCHEMATIC

THRUST DEFLECTOR-ACTUATED SEQUENCING VALVE FTX80439

Figure 71-48

(15) Fan Cascade-Actuated Sequencing Valve (See Figure 71-50)

(a) One fan cascade-actuated sequencing valve is mounted on the lower inner side of the left cascade vane support. The other is mounted on the upper inner side of the right cascade vane support. The piston end of the sequencing valve is attached to a feedback linkage actuated by the cascade vane actuating cylinders. Operation of the feedback linkage is as follows: the feedback linkage consists of a rotating crank attached to the end of the cascade linkage shaft. The crank is connected to the sequencing valve linkage shaft by a short link. Rotation of the cascade vane linkage shaft during cascade reverse thrust (deploy) and forward thrust (stow) positions causes the sequencing valve linkage shaft to move in and out of the sequencing valve.

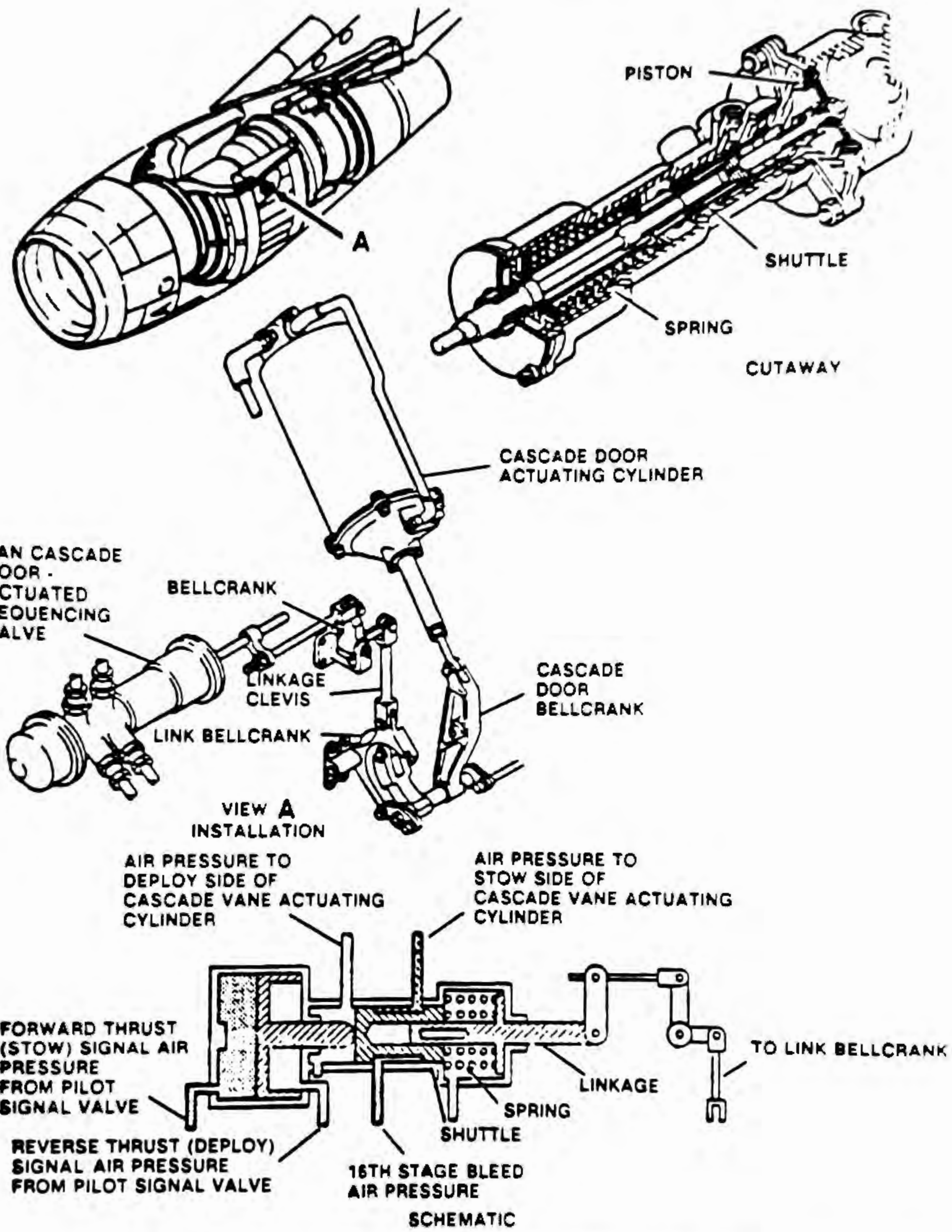
(16) Fan Cascade Door-Actuated Sequencing Valves (See Figure 71-51)

(a) One fan cascade door-actuated sequencing valve is mounted on the upper inner side of the left cascade support. The other cascade door-actuated sequencing valve is located on the lower inner side of the right cascade support. The piston end of the sequencing valve is connected by a linkage and a 90-degree bellcrank to a link bellcrank which follows the movement of the door linkage mechanism. Operation of the feedback linkage is as follows: the feedback linkage consists of a 90-degree bellcrank connected to a link bellcrank by means of a linkage clevis. The link bellcrank follows the movement of the cascade door actuating cylinder and transmits this movement back to the sequencing valve, causing the sequencing valve linkage shaft to move in and out of the sequencing valve.

19. Thrust Reverser Indicating System - Description and Operation

A. General (See Figure 71-52)

(1) A thrust reverser indicating system is provided to furnish primary and cascade door, thrust deflector, and cascade vane assembly positions to the flight crew. The thrust reverser indicating system contains two circuits: the engine cover door open circuit and the engine thrust brake indicator circuit.


PISTON
A
SHUTTLE
SPRING
CUTAWAY
CASCADE DOOR ACTUATING CYLINDER
FAN CASCADE DOOR - ACTUATED SEQUENCING VALVE
BELLCRANK
LINKAGE CLEVIS
CASCADE DOOR BELLCRANK
LINK BELLCRANK
VIEW A
INSTALLATION
AIR PRESSURE TO DEPLOY SIDE OF CASCADE VANE ACTUATING CYLINDER
AIR PRESSURE TO STOW SIDE OF CASCADE VANE ACTUATING CYLINDER
FORWARD THRUST (STOW) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
TO LINK BELLCRANK
LINKAGE
SPRING
SHUTTLE
REVERSE THRUST (DEPLOY) SIGNAL AIR PRESSURE FROM PILOT SIGNAL VALVE
16TH STAGE BLEED AIR PRESSURE
SCHEMATIC

FAN CASCADE DOOR-ACTUATED SEQUENCING VALVE FTX80442

Figure 71-51

(2) Indications for the engine doors open circuit and engine thrust brake circuit are provided by four dimmable THRUST BRAKE annunciators located on the instrument panel. The THRUST BRAKE annunciators may be tested by pressing the LIGHT TEST toggle switch located on the instrument panel.

(3) A THRUST BRAKE annunciator will begin flashing for the respective engine if one or both of the fan cascade doors are open; or if the primary door is open. If one or both fan cascade doors fail to close, or if the primary door fails to reach the stowed position, the annunciator will continue flashing.

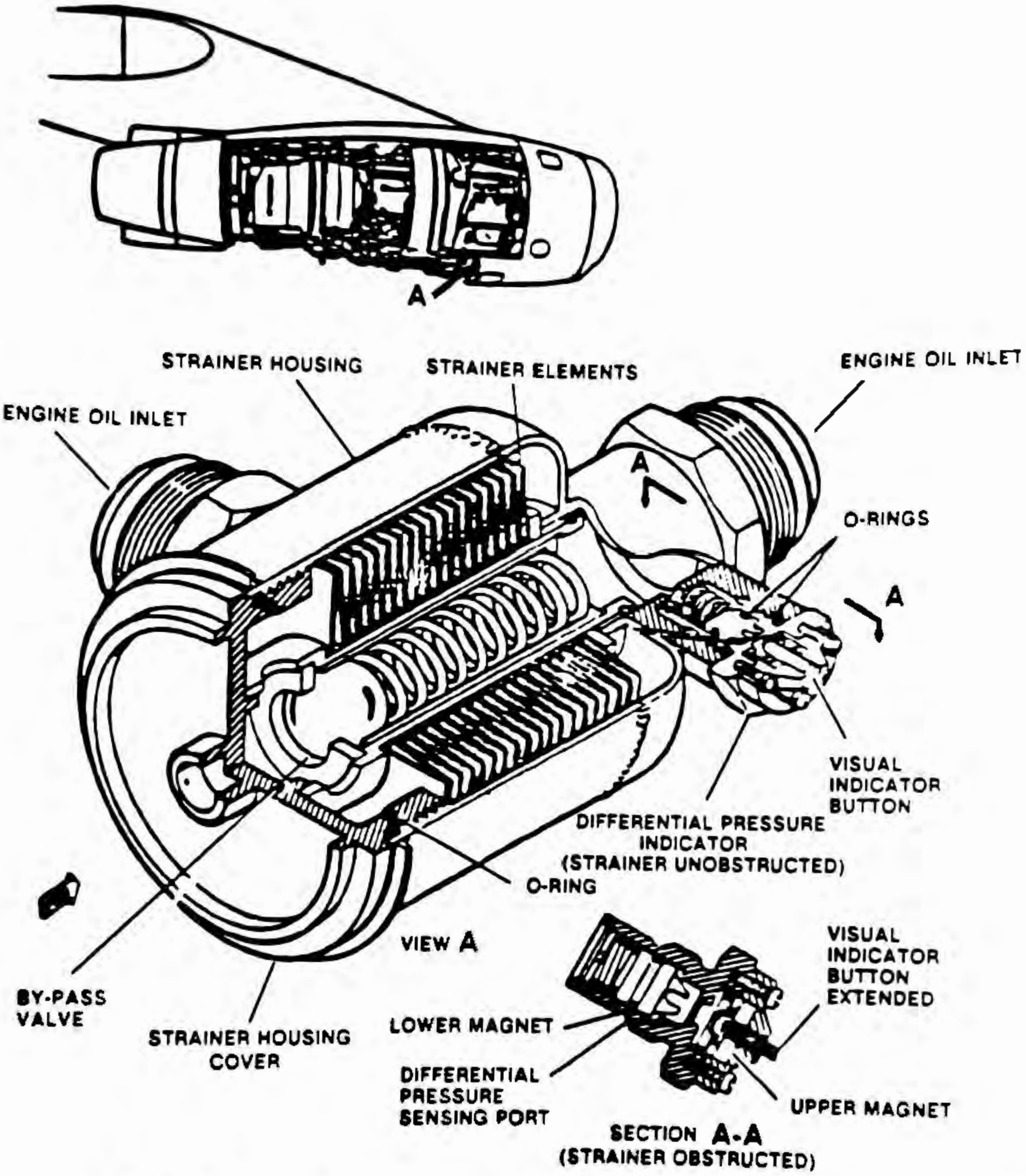
(4) The THRUST BRAKE annunciator will go on steady for the respective engine only when both cascade vane assemblies are in the fully deployed position, and the thrust deflectors are rotated into the reverse thrust position. If either left or right cascade vane assembly fails to open, or if the thrust deflectors fail to reach the reverse thrust position, the annunciator will continue to flash.

B. Component Description

(1) Engine Cover Doors Open Circuit (See Figure 71-53)

(a) The primary door open switch is located on the lower left side of the primary reverser case. The switch is single-pole, single throw, normally closed, and is spring-loaded close. The switch is actuated by an adjustable screw located on the inner surface of the primary door. When the primary door is closed, the screw actuates the spring-loaded mechanism, allowing the switch to open. When the primary door moves to the open position, the screw moves away from the switch, allowing the spring to close the switch.

(b) A cascade door open switch is located in each cascade vane support assembly, adjacent to the cascade door operating mechanism and is mounted on the inner surface of the cascade vane support. The switch is single-pole, single throw, normally closed, and is actuated by an adjustable, spring-loaded stop switch assembly, attached to the cascade door actuating linkage.



ENGINE SCAVENGE OIL STRAINER -- SCHEMATIC FTX80450

Figure 71-57

(2) Engine Thrust Reverser Indicator Circuit (See Figure 71-53)

(a) The thrust deflectors deployed switch is located on the upper left side of the primary reverser case. The switch is single-pole, single throw, normally open, and is actuated by an adjustable screw located on the left deflector actuating arm. The switch is closed when the deflectors reach the fully deployed position.

(b) A cascade vane assembly deployed switch is located in each cascade vane support, at the aft edge of the cascade vane assembly, and mounted on the inner surface of the cascade vane support. The switch is single-pole, single throw, and normally open. A spring-loaded switch bumper is installed at the trailing edge of the cascade vane support, and is adjusted to actuate the switch closed when the cascade vane assembly reaches the fully deployed position.

(3) Operation

(a) The engine cover doors open and engine thrust brake annunciators receive 28 VDC power through the CAPT ANNUNCIATOR circuit breaker located on the upper EPC circuit breaker panel.

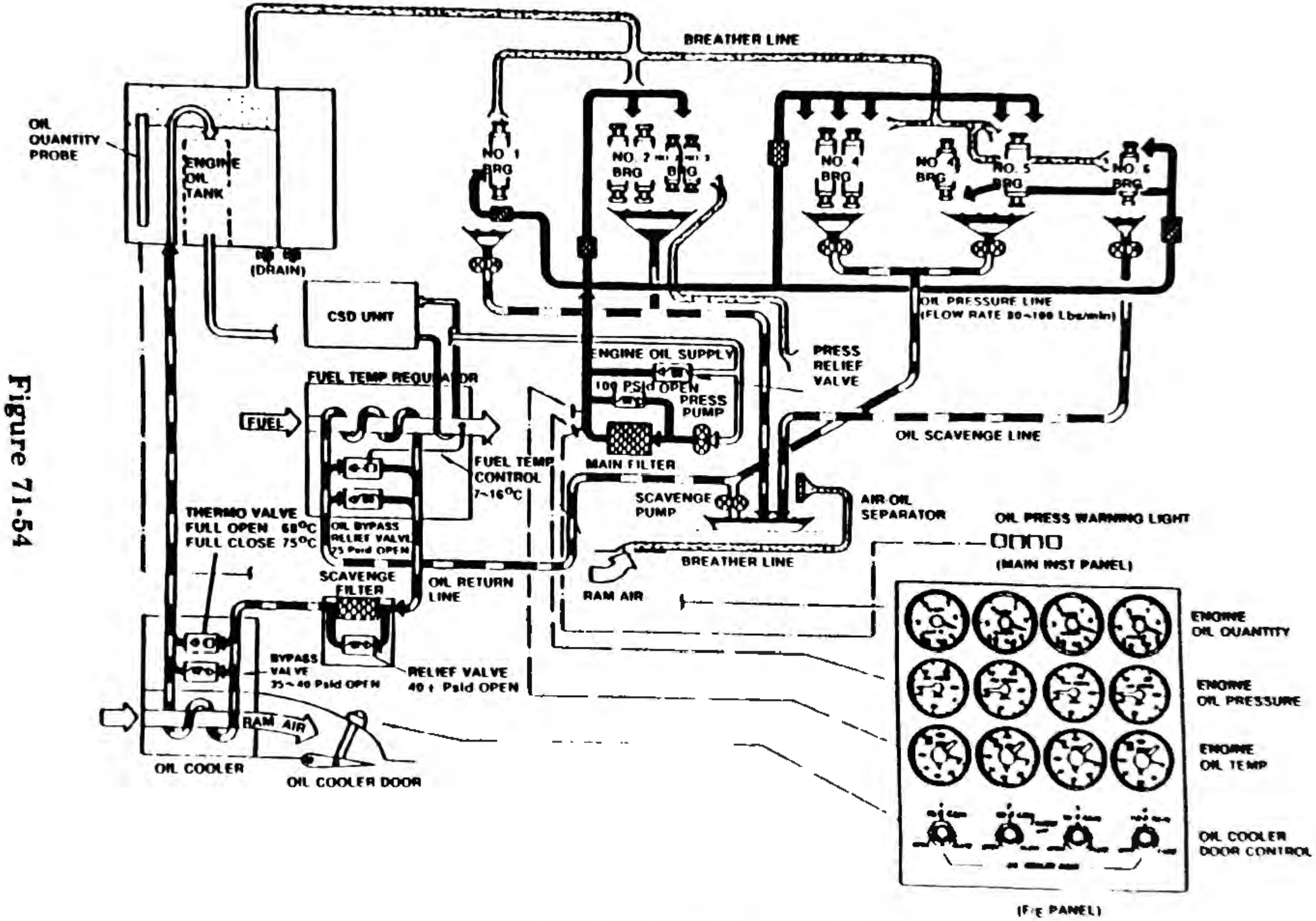
(b) Three engine cover door switches in the circuit are individually grounded in parallel and are connected, via a flasher, to the annunciator. The annunciator will flash when any of the cover door switches is closed.

(c) Three engine thrust brake indicating switches in the circuit are connected in series to ground at the deflectors deployed switch. This circuit is connected directly to the annunciator bypassing the flasher, causing the annunciator to go on steady when all three switches are closed.

20. General - Description and Operation

A. Description (See Figure 71-54)

(1) The engine oil system is a self-contained high-pressure system which supplies lubrication to the main engine bearings and accessory drives. A scavenge system removes oil from the bearing compartments and



JT-3D-3B OIL SYSTEM

FTX80446

Figure 71-54

21. Storage - Description and Operation

A. General (See Figure 71-55)

(1) The engine oil tank is used to store and supply oil to the engine oil pump and lubricating system. The tank is a stainless steel shell divided into two separate compartments. One compartment forms the reservoir for the engine oil system, the other, the reservoir for the generator drive transmission oil system when used. The tank is mounted in a cradle on the forward upper left side of the engine case and is secured by three straps. Three ports are located at the top of the generator drive transmission oil compartment of the tank. One port vents into the engine oil tank fitting. The tank is provided with a scupper drain sump and drain line connection, two self-locking filler caps with dipsticks, internal baffle, internal deaerator, two adapters, and provision for an oil quantity transmitter.

(2) The two self-locking filler caps with attached dipsticks are located in the scupper drain sump. The drain line connects between the scupper sump and the overboard drain.

(3) An internal baffle is installed in the tank to minimize oil sloshing.

(4) An adapter assembly is clamped to a mounting boss on the bottom of each compartment of the oil tank. The engine oil compartment adapter has an inlet connection, an outlet connection, and a drain valve. The generator drive transmission oil compartment adapter has an outlet connection and a drain valve. Moving the drain valve shaft 90 degrees in a counter-clockwise direction opens the valve.

(5) The internal deaerator is attached at its base to the engine oil tank compartment adapter. The deaerator separates air from oil returned to the tank, the air being vented through the tank vent into the diffuser. The bottom slots in the deaerator are so located that they are submerged even at low oil levels.

(6) The engine oil tank compartment is provided with a flange to accommodate an oil quantity transmitter.

Oil Tank Compartment	US Gallons
Total capacity	9.8
Total usable engine oil	9.7
Expansion space (22 percent)	2.2
Sump	0.1

22. Distribution - Description and Operation

A. General

(1) The engine is equipped with a high-pressure oil system to lubricate and cool the engine bearings and accessory drives. Components consists of the main oil pump, oil pressure relief valve, main oil filter, five oil scavenge pumps, oil cooler and bypass valve, oil cooler door control system, oil cooler door actuator, external oil tubes, and scavenge oil strainer.

(2) The main oil pump is located in the main accessory drive case. The pump supplies oil system pressure.

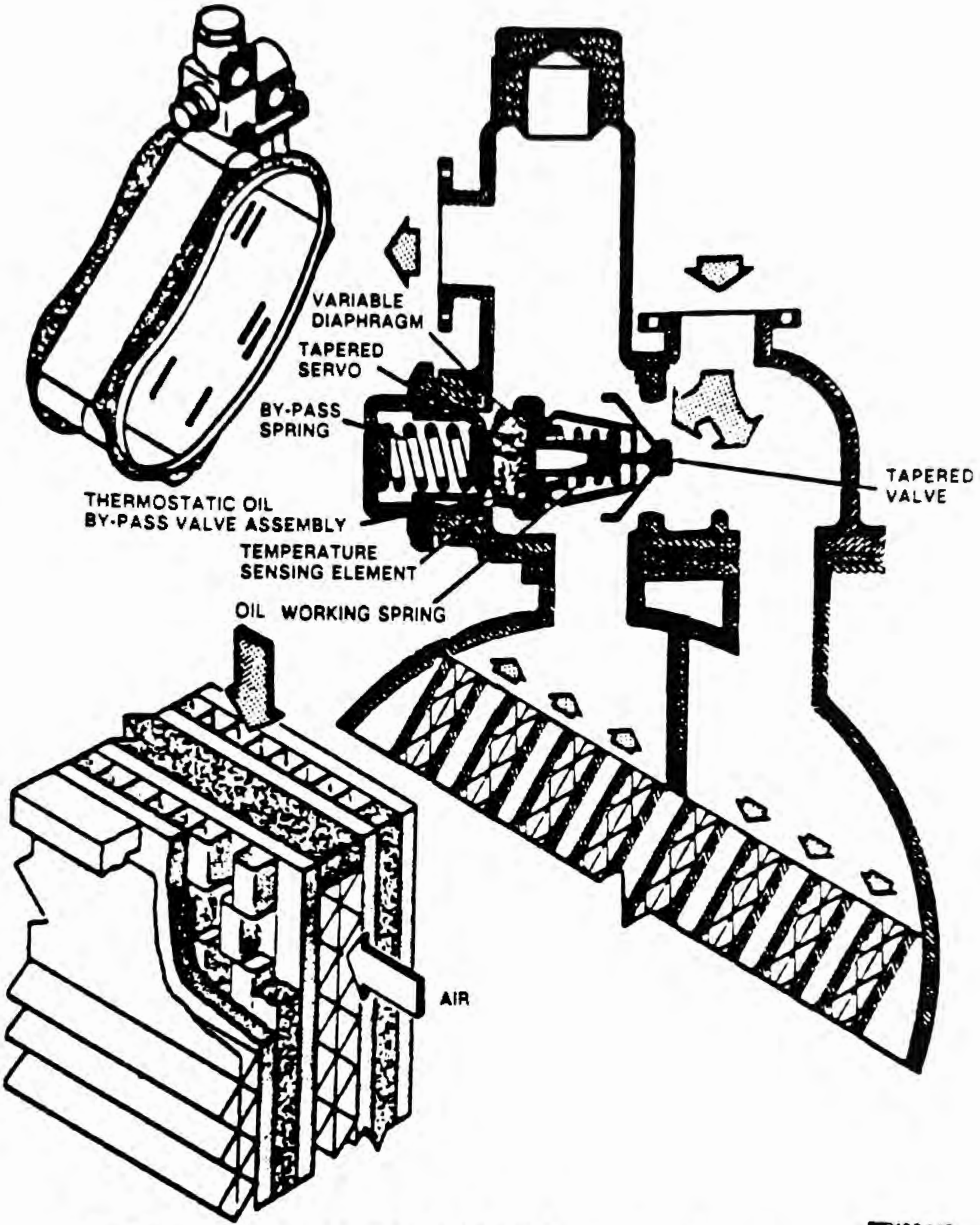
(3) The oil pressure relief valve is located on the lower right side of the main accessory drive case. The valve controls oil system pressure between 40 to 55 psig, at the engine bearings.

(4) The main oil filter is located forward, on the intermediate case flange. The filter removes contaminants from the oil downstream of the pressure pump.

(5) The five oil scavenge pumps are located within the inlet accessory drive case, main accessory drive case, diffuser case, and No. 6 bearing scavenge pump housing. The scavenge pumps return the oil to the tank via the fuel temperature regulator and oil cooler.

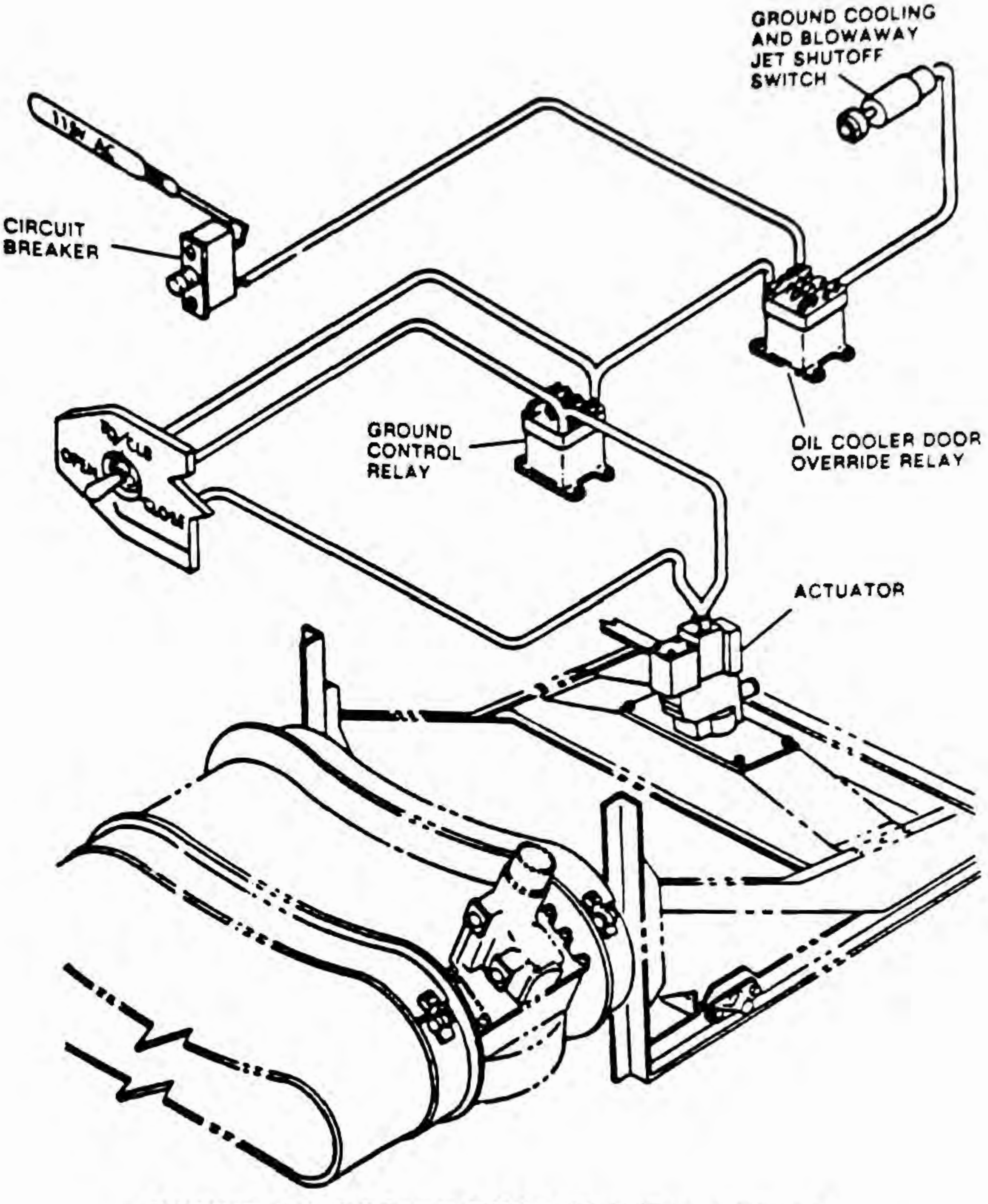
(6) Engine lubricating oil is cooled by the oil cooler mounted in the lower left side of the nose cowl. The bypass valve mounted on the oil cooler, regulates the oil temperature within a range most advantageous for engine operation.

(7) The oil cooler door control system controls the flow of cooling air directed to the oil cooler.



ENGINE OIL COOLER AND BYPASS VALVE -- SCHEMATIC

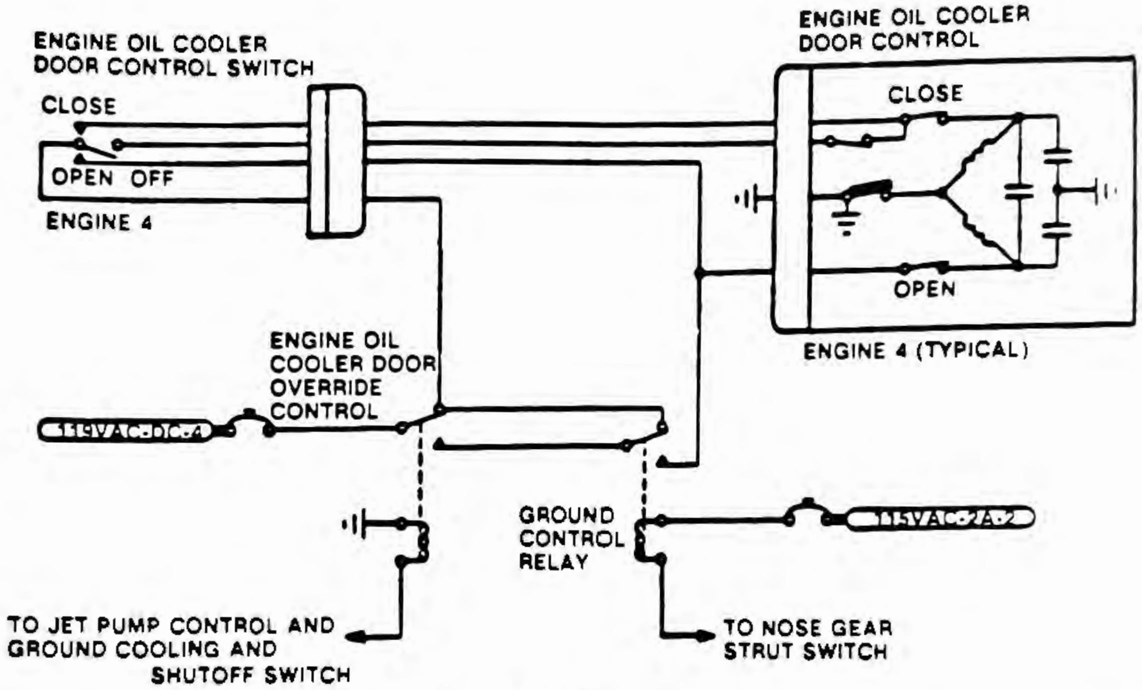
Figure 71-56


GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
115V AC
CIRCUIT BREAKER
TO/CLS
OPEN
CLOSE
GROUND CONTROL RELAY
OIL COOLER DOOR OVERRIDE RELAY
ACTUATOR

ENGINE OIL COOLER DOOR CONTROL SYSTEM -- SCHEMATIC

FTX80451

Figure 71-58


ENGINE OIL COOLER DOOR CONTROL SWITCH
CLOSE
OPEN
OFF
ENGINE 4
ENGINE OIL COOLER DOOR CONTROL
CLOSE
OPEN
ENGINE 4 (TYPICAL)
ENGINE OIL COOLER DOOR OVERRIDE CONTROL
GROUND CONTROL RELAY
TO JET PUMP CONTROL AND GROUND COOLING AND SHUTOFF SWITCH
TO NOSE GEAR STRUT SWITCH

ENGINE OIL COOLER DOOR CONTROL -- SCHEMATIC FTX80452

Figure 71-59

27. Engine Oil Quantity Indicating System - Description and Operation

A. General (See Figure 71-61)

(1) The engine oil quantity system provides a remote indication of oil quantity. The system consists of a transmitter mounted on the oil tank, and an indicator mounted in the flight compartment. The system is supplied with 115 VAC from AC bus 1, 2, 3, or 4 through a circuit breaker located on the main circuit breaker panel. If the power source is interrupted, the indicator pointer goes against the stop past zero.

(2) The transmitter, is basically, two electrical capacitors comprised of a series of concentric tubes which reach from the top to the bottom of the engine oil tank. A constant value capacitor is located at the lower end of the transmitter.

(3) The indicator is integrally lighted, hermetically sealed, and contains a self-balancing capacitance bridge net worth, an amplifier, and a pointer control motor.

B. Operation

The capacitance bridge is made up of a constant value capacitor, variable capacitor, and a potentiometer. A change in oil level changes the value of the variable capacitor which unbalances the bridge, sending a signal to the indicator amplifier. The amplifier output drives the pointer control motor which moves the potentiometer arm in a direction to null out the bridge unbalance. Movement of the potentiometer wiper arm reflects on the indicator pointer which registers the oil tank quantity.

23. Engine Oil Pressure Indicating Systems - Description and Operation

A. General (See Figure 71-62)

(1) Engine oil pressure indicating systems include oil pressure indicating and oil low-pressure caution. The oil pressure indicating system consists of a transmitter mounted on the main oil filter, and an indicator mounted on a panel in the flight compartment. The system is supplied with 28 VAC from instrument bus 2 or 3 through a circuit breaker located on the main circuit breaker panel. The system is in operation when the airplane electrical buses are energized. If the power source is interrupted, the indicator pointer goes against the stop past zero.

(2) The transmitter is a variable reluctance type consisting of a diaphragm, magnetic armature, two stationary coils, and a housing. The housing is provided with a pressure port, vent, port, and a removable plug cap which permits access for calibration adjustments.

(3) The indicator is integrally lighted and hermetically sealed, and consists of a stationary coil, rotor and hairspring assembly connected to a pointer, bearings, resistor, and thermistors. The indicator is not adjustable at field maintenance level.

(4) The low-pressure caution system consists of a pressure switch mounted on the main oil filter and an indicating light mounted on a panel in the flight compartment. The system is supplied with 28 VDC from DC bus 1 or 4 through a circuit breaker located on the main circuit breaker panel.

(5) The low-pressure switch is hermetically sealed, pressure actuated, and consists of a diaphragm, mechanical linkage, switch, and a housing. The housing is provided with a pressure port, vent port, and an electrical connector.

B. Operation

(1) The oil pressure transmitter and oil low-pressure caution switch sense the engine oil system pressure downstream of the oil cooler. The oil pressure transmitter and indicator function as an AC bridge. Any change in pressure sensed by the transmitter causes the diaphragm to move the armature, changing the reluctance of the transmitter coils. This change in reluctance unbalances the bridge network, creating a greater current flow in one side of the bridge. The current flow in the circuit results in movement of the indicator rotor and pointer.

(2) The oil low-pressure caution indicating light is normally on until an increasing pressure of 40 psi is obtained, at which time, the switch contacts open and the light goes off. When the system pressure decreases to 35 (± 1) psi, the switch contacts close completing a circuit, and the light comes on.

1. General - Description and Operation

A. Description (See Figures 71-1 & 71-2)

(1) The aircraft is powered by four Pratt & Whitney JT3D long duct, axial flow turbofan engines. Each engine in the installed configuration is a demountable powerplant.

(2) The demountable power plant is suspended from a pylon, which extends below and partially forward of the wing leading edge, by a three-point mounting system.

(3) The powerplant cowling sections join together around the engine and accessories to form a completely enclosed nacelle. This nacelle provides complete powerplant protection and smooth, unobstructed airflow during flight.

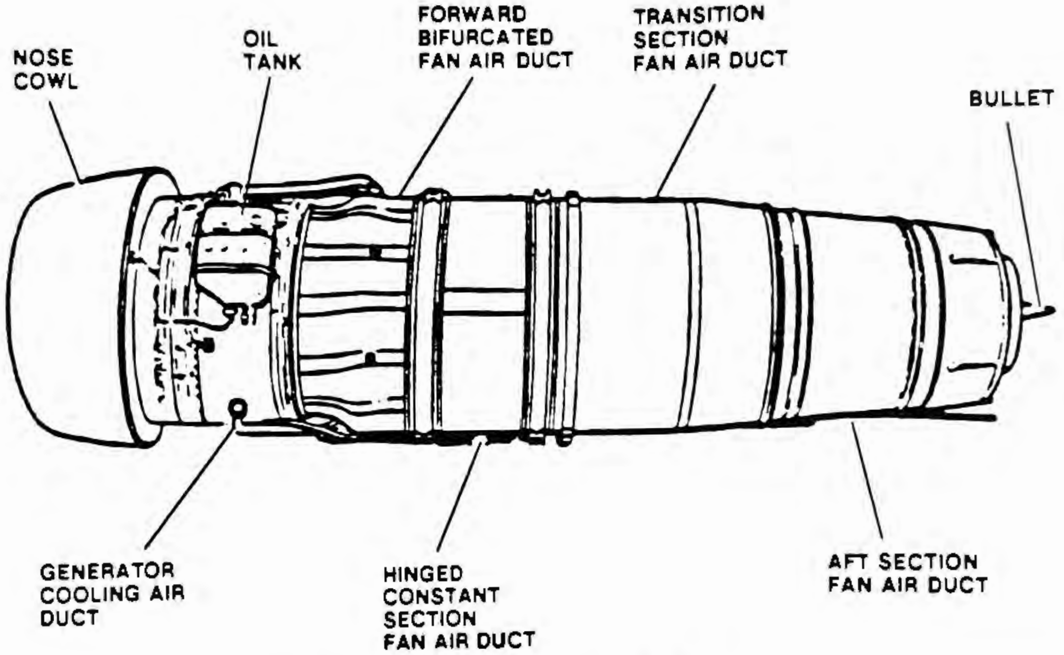
(4) Each powerplant, after installation on the airplane, is protected by a fire detection system and a fire extinguishing system.

(5) The demountable powerplant has the following approximate weight.

Total demountable powerplant, fully serviced, including the nose cowl, bullet, cowl doors, aft cowl, thrust reverser, and exhaust nozzle, is approximately 6484 lbs.

(6) Individual major components of the powerplant have the following approximate weights.

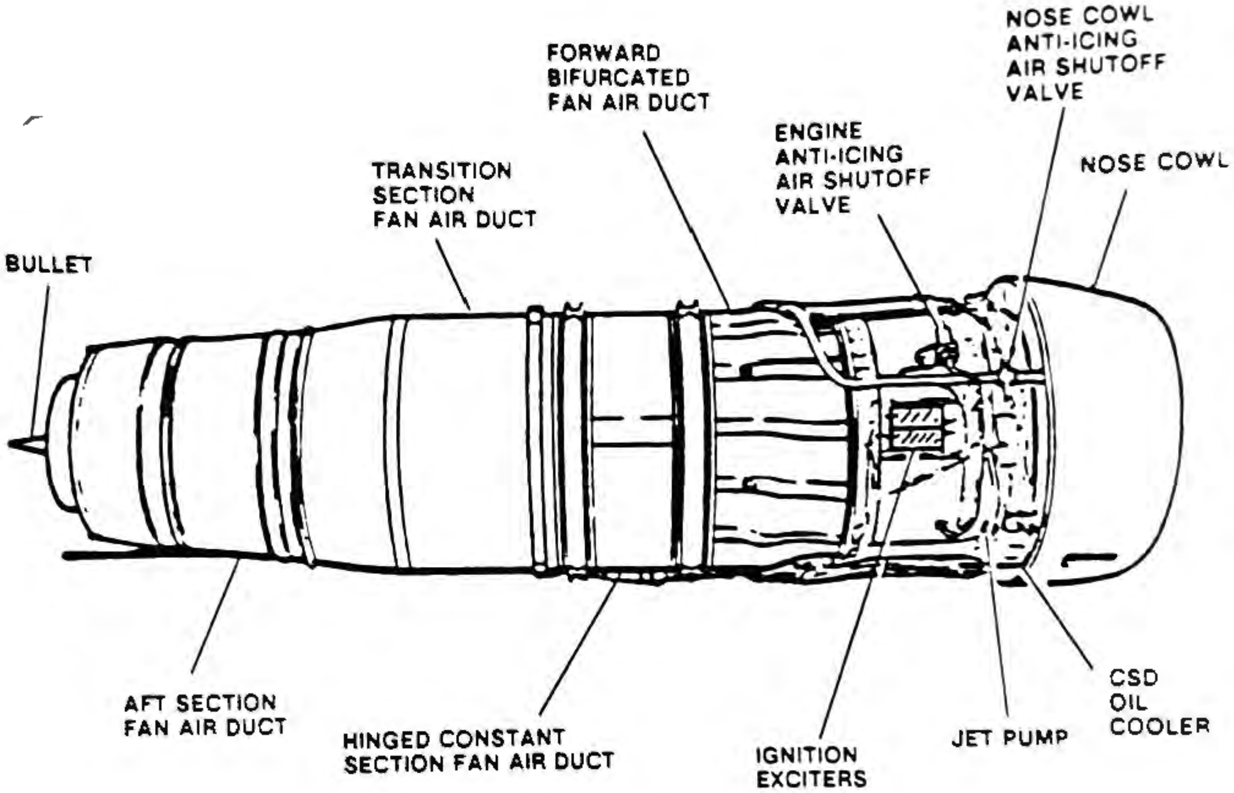
Nose cowl	137 lbs
Bullet	12 lbs
Right cowl door	86 lbs
Left cowl door	86 lbs
Left aft cowl	35 lbs
Right aft cowl	33 lbs


NOSE COWL
OIL TANK
FORWARD BIFURCATED FAN AIR DUCT
TRANSITION SECTION FAN AIR DUCT
BULLET
GENERATOR COOLING AIR DUCT
HINGED CONSTANT SECTION FAN AIR DUCT
AFT SECTION FAN AIR DUCT

POWER PLANT - LEFT SIDE

FTX80546

Figure 71-1


NOSE COWL ANTI-ICING AIR SHUTOFF VALVE
FORWARD BIFURCATED FAN AIR DUCT
ENGINE ANTI-ICING AIR SHUTOFF VALVE
NOSE COWL
TRANSITION SECTION FAN AIR DUCT
BULLET
AFT SECTION FAN AIR DUCT
HINGED CONSTANT SECTION FAN AIR DUCT
IGNITION EXCITERS
JET PUMP
CSD OIL COOLER

POWER PLANT - RIGHT SIDE

FTX80547

Figure 71-2

Exhaust nozzle assembly	156 lbs

(7) The demountable powerplant has the following approximate measurements.

(a) Total demountable powerplant length - 19.6 ft

(b) Maximum demountable powerplant diameter - 6 ft

(8) The powerplant, when installed, has the following approximate height from the ground.

(a) Height from the ground to the outboard powerplant lowest point 4.5 ft

(b) Height from the ground to the inboard powerplant lowest point 2.5 ft

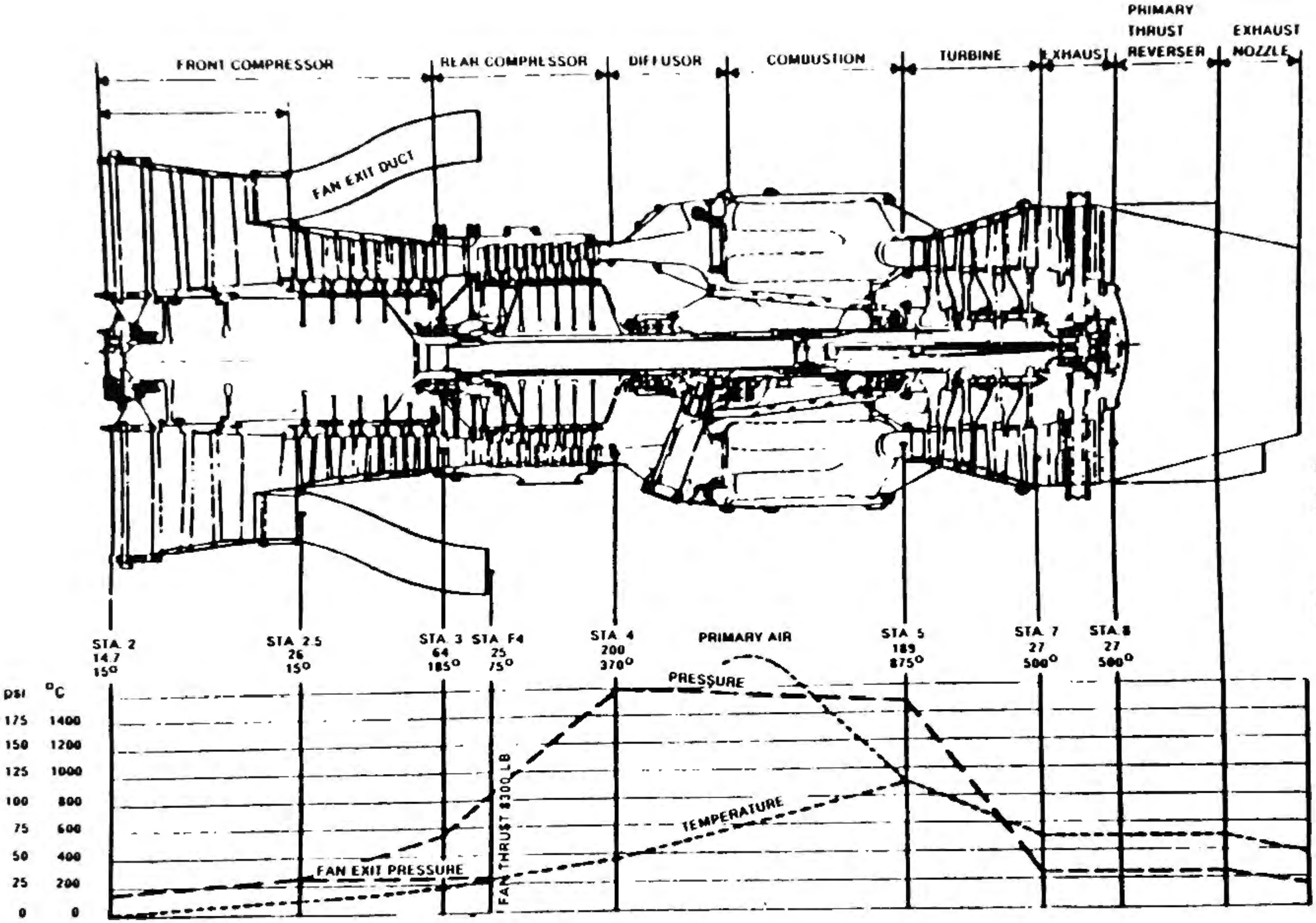
(9) The engine oil tank has the following approximate capacities.

Oil tank capacity	5.8 US gallons
Usable oil	5.2 US gallons
Expansion space (approximately 28 percent)	1.6 US gallons
Sump	0.1 US gallons

B. Engine (See Figures 71-3 & 71-4)

(1) The JT3D long duct, axial-flow turbofan engine has a 15-stage split compressor, 4-stage split turbine, an 8-can annular-type combustion chamber, and two accessory drive cases.

(2) The 15-stage compressor is divided into two mechanically independent sections. The low-pressure compressor section consists of the first eight stages of the compressor. The first two stages are the fan stages and are much larger in diameter than the remaining six. This section of the compressor is driven by the last three stages of the turbine. The



TURBO-FAN ENGINE CONFIGURATION AND NOMINAL OPERATING CHARACTERISTICS FOR STATIC SEA LEVEL TAKE-OFF THRUST

FTX80549

Figure 71-3

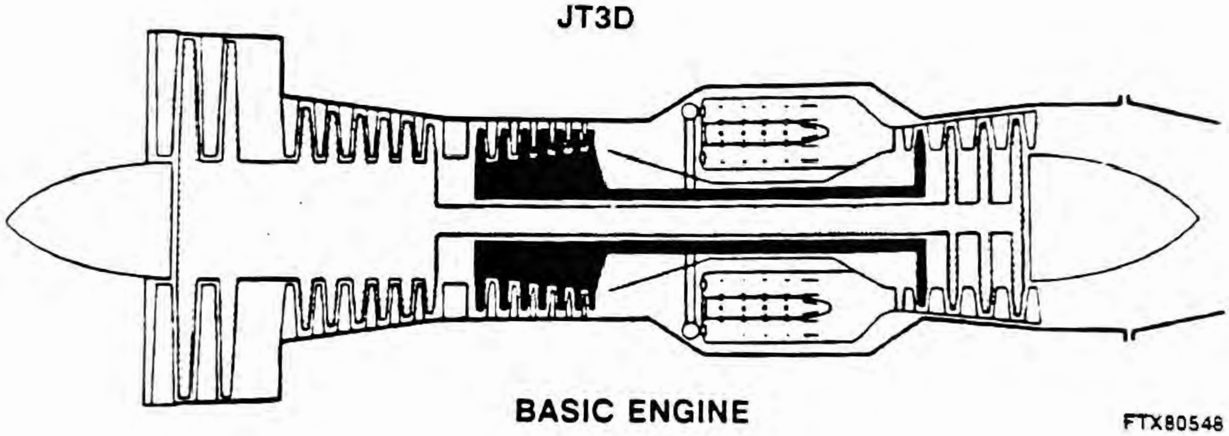


Figure 71-4

high-pressure compressor section consists of the last seven stages of the compressor and is driven by the first stage of the turbine. This section of the compressor also drives the main accessory drive case.

(3) The 4-stage split turbine is divided into two mechanically independent sections. The low-pressure section consists of the last three stages of the turbine and high-pressure section consists of the first stage.

(4) The eight cans of the can annular-type combustion chamber are numbered in a clockwise direction, viewed from the aft end of the engine, with the No. 1 can located to the right of top center.

(5) The two accessory drive cases provided on the engine are the inlet and the main accessory drive cases. The inlet accessory drive is internally driven by the front compressor, and the main accessory drive is internally driven by the rear compressor. Both accessory drives are lubricated by the engine oil system.

(6) A fan duct system for delivering air from the low pressure compressor fan section to the exhaust nozzle is installed on the engine. The fan duct system consists primarily of two composite ducts, one on each side of the engine, which extend from a common bifurcated duct installed on the engine fan discharge case to the aft ducts mounted on the exhaust nozzle. Each of the composite ducts is divided into the following four sections to facilitate maintenance on the engine and the accessories.

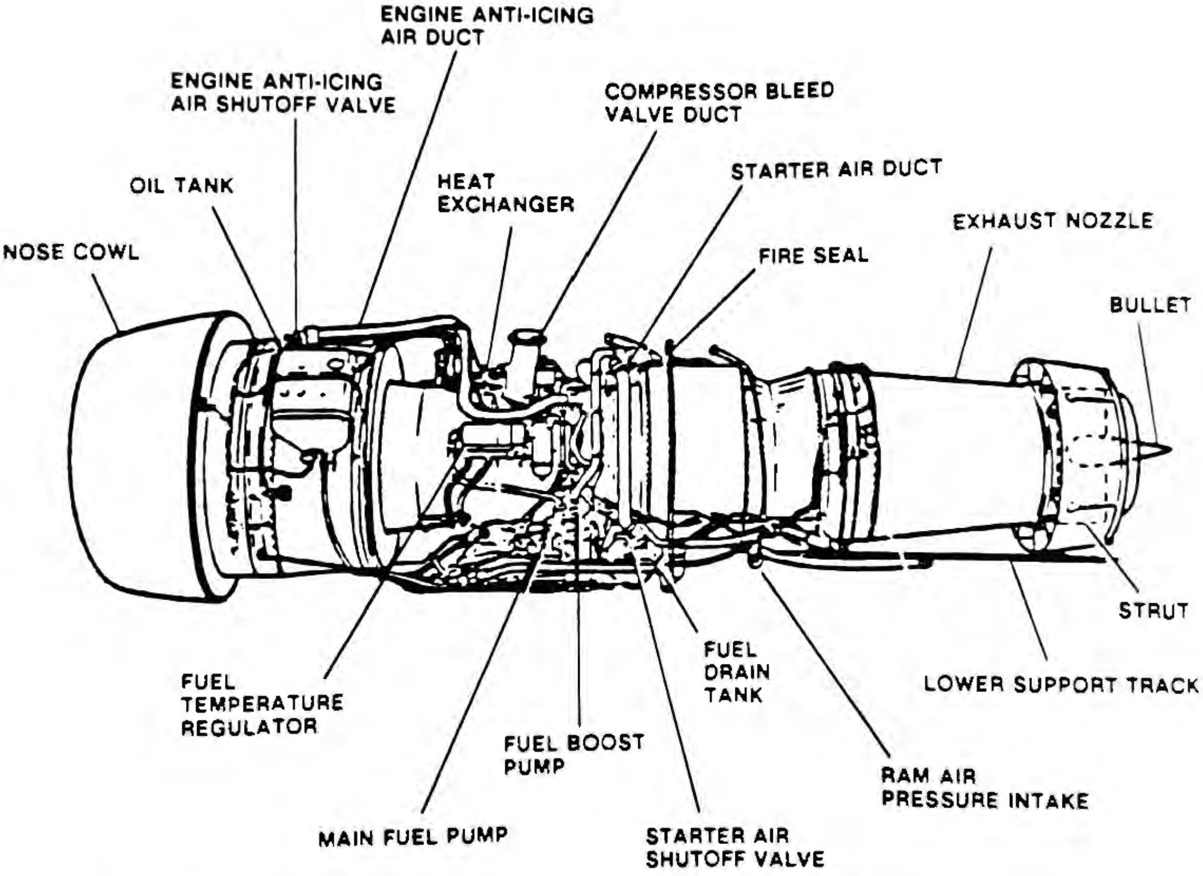
(a) Bifurcated duct

(b) Constant section duct

(c) Transition duct

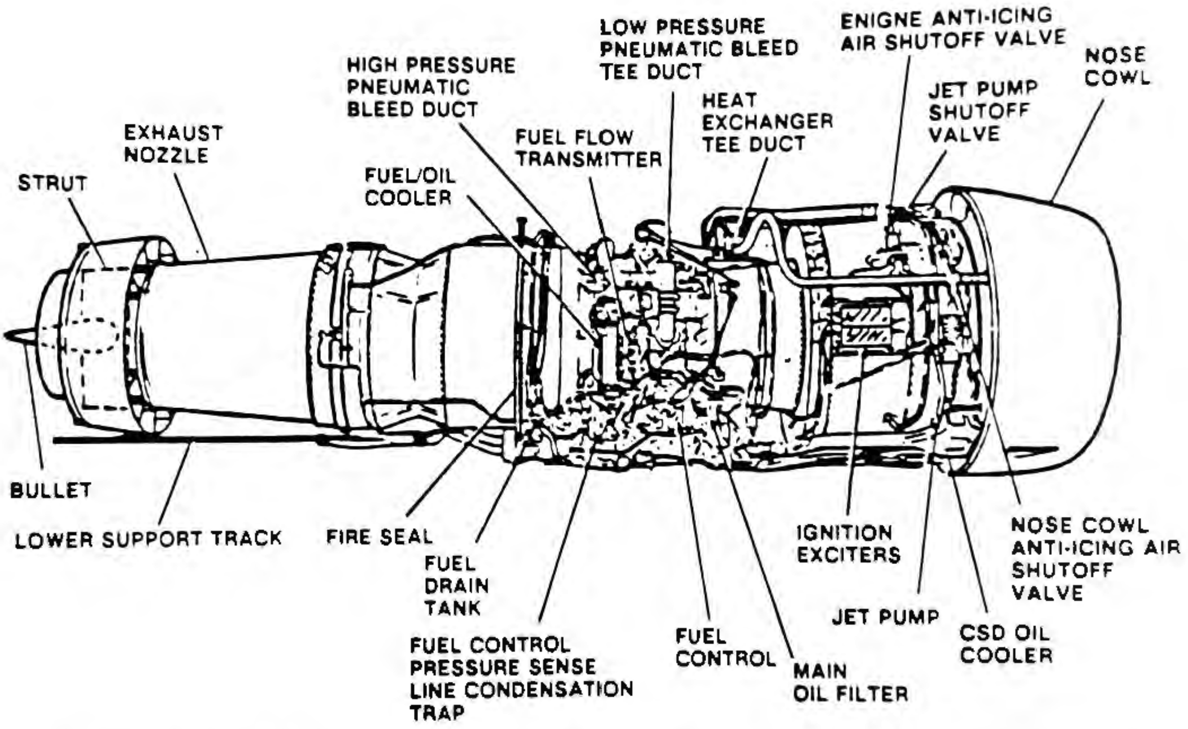
(d) Aft duct

Dynamic seal joints are included in the duct system to provide for movement resulting from thermal growth of the engine and the ducts.



POWER PLANT LEFT SIDE WITH FAN AIR DUCTING REMOVED FTX80550

Figure 71-5



POWER PLANT RIGHT SIDE WITH FAN AIR DUCTING REMOVED FTX80551

Figure 71-6

C. Engine Fuel and Control

(1) The fuel and control system functions to pump, filter, distribute, and meter the fuel consumed during engine operation.

(2) A fuel deicing system, using heat transfer of hot engine lubricating oil, eliminates ice formed in the engine fuel system.

D. Ignition

(1) Ignition is supplied by a dual ignition system through two shielded high-tension leads connected to igniter plugs located in engine combustion chambers No. 4 and No. 5.

(2) The ignition system is controlled from the flight compartment.

E. Air

(1) The air system consists of engine anti-icing, accessory cooling, and compressor bleed.

(2) Engine anti-icing is supplied from the 12th-stage bleed air through valves which are controlled from the flight compartment.

(3) Accessory cooling on the ground is provided by a jet pump system. Inflight cooling is provided by ram air.

(4) The compressor bleed system provides operational flexibility during engine starting, acceleration, and operation at low thrust settings.

F. Engine Controls

(1) Each engine is remotely controlled from the flight compartment by three major levers: the throttle, the throttle reverser, and the fuel shutoff. These levers are located on the control pedestal.

(2) The throttle controls the fuel flow, thus regulating the thrust output produced by the engine. The thrust reverser lever hinged to the top of the throttle lever, controls the operation of the thrust reverser and fuel flow for variable thrust requirements.

(3) The fuel shutoff lever controls the fuel supplied to the engine fuel control.

G. Engine Indicating

(1) The engine indicating system uses inlet and exhaust duct air pressures, exhaust gas temperatures, and compressor rotor speeds as a means of monitoring engine operation.

(2) The pressure ratio system senses inlet and exhaust duct air total pressures. The computed ratio existing between pressures is displayed on an indicator in the flight compartment.

(3) Six thermocouple probes installed in the engine exhaust duct provide an average temperature which is displayed on an indicator in the flight compartment.

(4) High- and low-pressure rotor speeds are displayed on percentage-type indicators in the flight compartment. Each system derives its power from an engine-driven tachometer generator.

H. Exhaust

(1) Engine exhaust is ducted overboard through the exhaust nozzle. The exhaust nozzle is not an integral part of the thrust reverser and can be removed at field maintenance level.

(2) The aircraft thrust reverser system consists of a translating ring. and two deflector doors which are faired into the sides of the translating ring when in the forward position. In operation, the translating ring is moved aft and the deflector doors rotate into the exhaust stream of the engine to provide thrust reversal. Thrust reverser system operation is mechanically, electrically, and pneumatically controlled, and hydraulically powered.

I. Oil

(1) Each engine is equipped with a self-contained high-pressure oil system, which supplies both lubrication and cooling for the engine bearings, and accessory drives. The oil system pressure, flow, and temperature are regulated within specified limits.

(2) Indicating systems are provided which permit flight compartment observation of oil system parameters during engine operation.

J. Starting

(1) The starting system functions to rotate the engine high-pressure compressor rotor until self-sustained rotation is achieved by internal combustion.

(2) Pneumatic pressure, controlled by a solenoid-actuated starter air shutoff valve, powers the air turbine starter.

(3) The starting system is controlled from the flight compartment.

2. Cowling - Description and Operation

A. General

(1) The cowling sections attach together around the outer diameter of the engine to form a completely enclosed nacelle. This provides protection for the exterior of the engine and accessories, and provides a smooth, unrestricted airflow around the engine during flight. The cowling consists of the nose cowl, inlet bullet, cowl doors, and aft cowl. The thrust reverser translating ring completes the fairing of the engine.

(2) The pylon apron completes the upper portion of the cowling and provides the attach points for the cowl doors and the aft cowl.

B. Nose Cowl (See Figures 71-7 & 71-8)

(1) The nose cowl is the foremost section of the cowling and attaches directly to the engine inlet flange. The leading edge contains a duct which directs engine anti-icing air around the inside of the nose cowl.

(2) An air inlet scoop, located on the right side of the nose cowl provides cooling air for the CSD oil cooler.

(3) Removable panels in the nose cowl aft bulkhead provide access for maintenance on ducts and other components which are installed in the nose cowl.

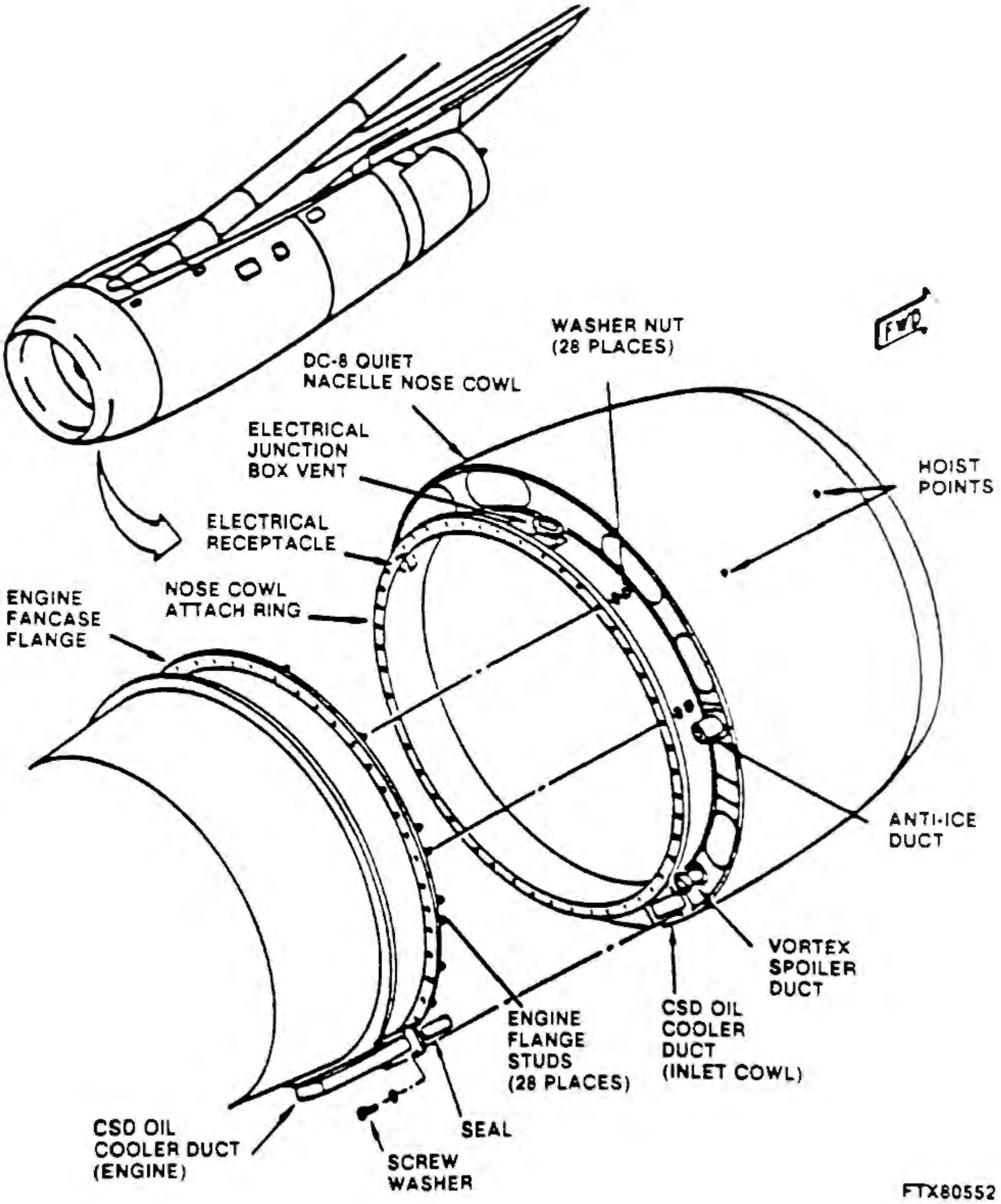
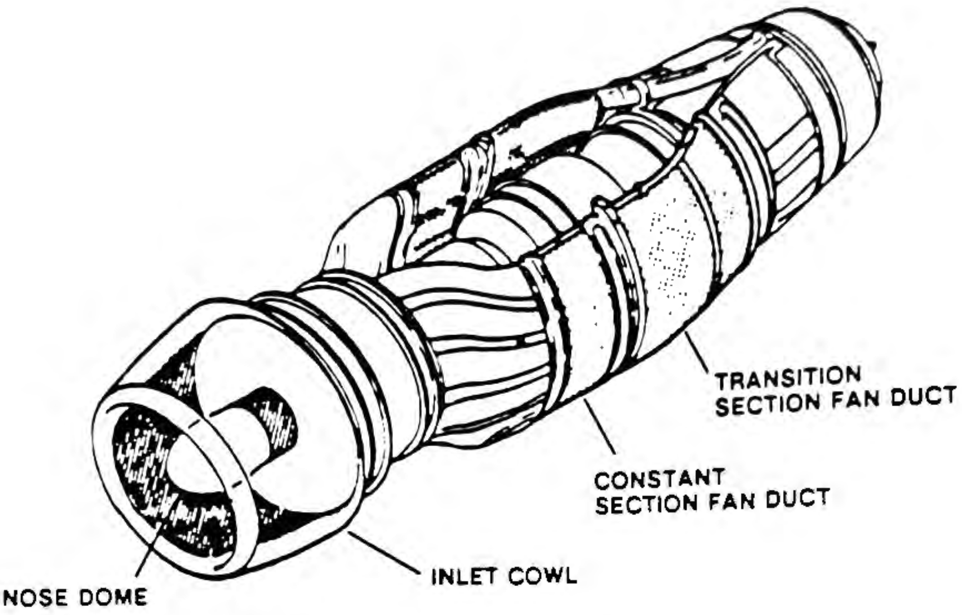
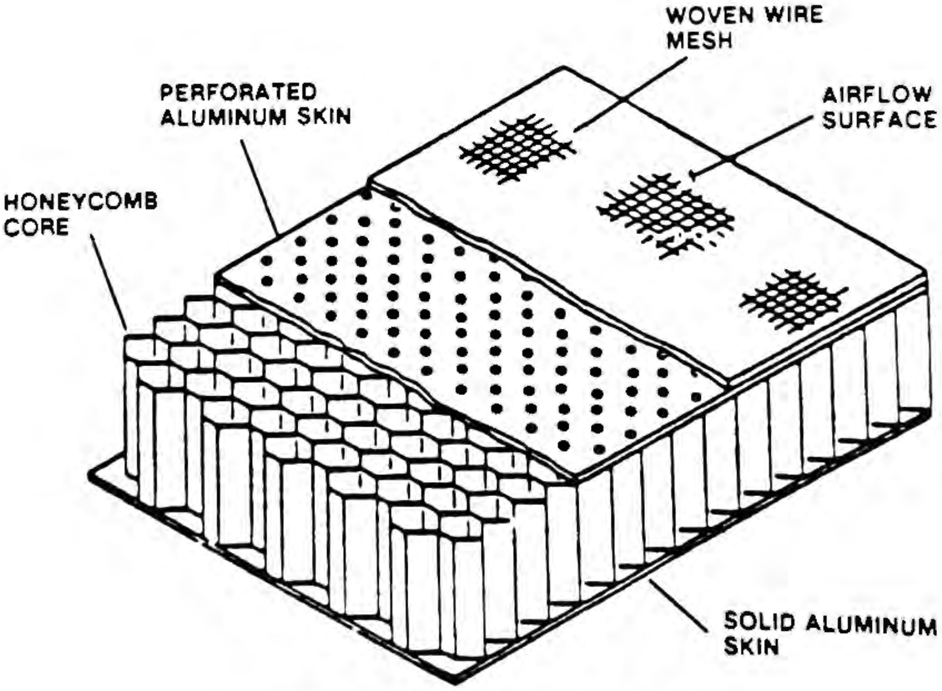

WASHER NUT (28 PLACES)
FWD
DC-8 QUIET NACELLE NOSE COWL
ELECTRICAL JUNCTION BOX VENT
HOIST POINTS
ELECTRICAL RECEPTACLE
ENGINE FANCASE FLANGE
NOSE COWL ATTACH RING
ANTI-ICE DUCT
VORTEX SPOILER DUCT
CSD OIL COOLER DUCT (INLET COWL)
ENGINE FLANGE STUDS (28 PLACES)
SEAL
CSD OIL COOLER DUCT (ENGINE)
SCREW WASHER
FTX80552

Figure 71-7



ACOUSTICALLY TREATED COMPONENTS



TYPICAL DYNAROHR PANEL

FTX80553

Figure 71-8

C. Inlet Bullet (See Figure 71-9)

The inlet bullet, installed on the engine inlet accessory drive case flange, provides smooth airflow into the engine compressor and protects accessories installed on the accessory drive case. The N_1 tachometer generator and the P_t2 inlet pressure sensing probe are housed in the inlet bullet.

D. Cowl Doors (See Figures 71-10 and 71-11)

(1) The cowl doors cover the major portion of the engine and accessories, providing an unobstructed surface from the nose cowl to the aft cowl. The doors are attached to the pylon apron by hinges equipped with quick-release type pins. Rotary type tension latches are installed in the doors to retain the doors in the closed position.

(2) Integral struts, stowed on the inner surface of the doors, can be released and engaged with engine mounted brackets to support the doors in the open position.

(3) An inlet duct in the left cowl door provides cooling air for the generator. The right cowl door inlet duct provides cooling air for the engine compartment.

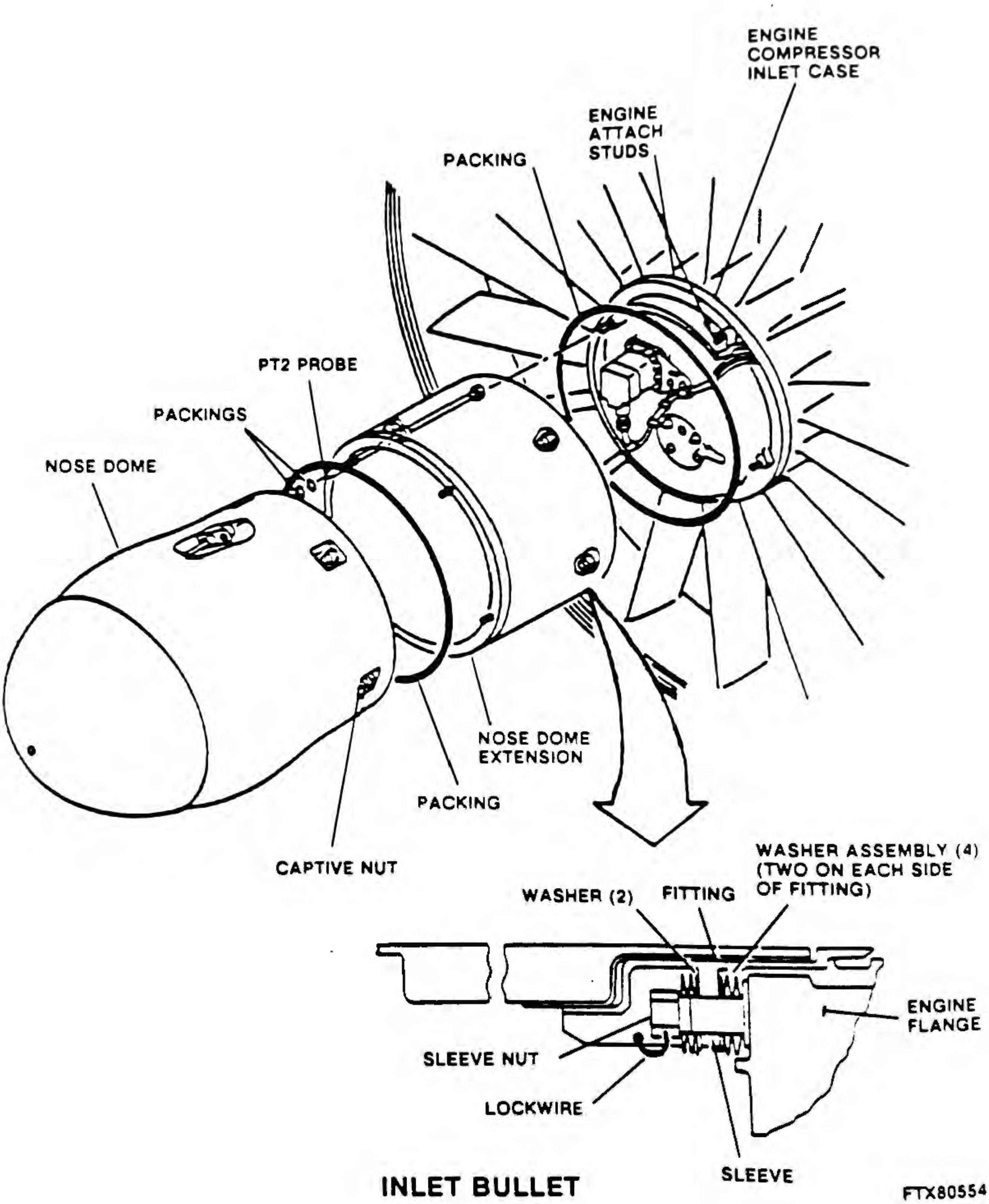
(4) A pressure relief door in each cowl door relieves excess compartment pressure.

(5) Limited access doors are provided for servicing when the cowl doors are closed.

E. Aft Cowl (See Figures 71-12 and 71-13)

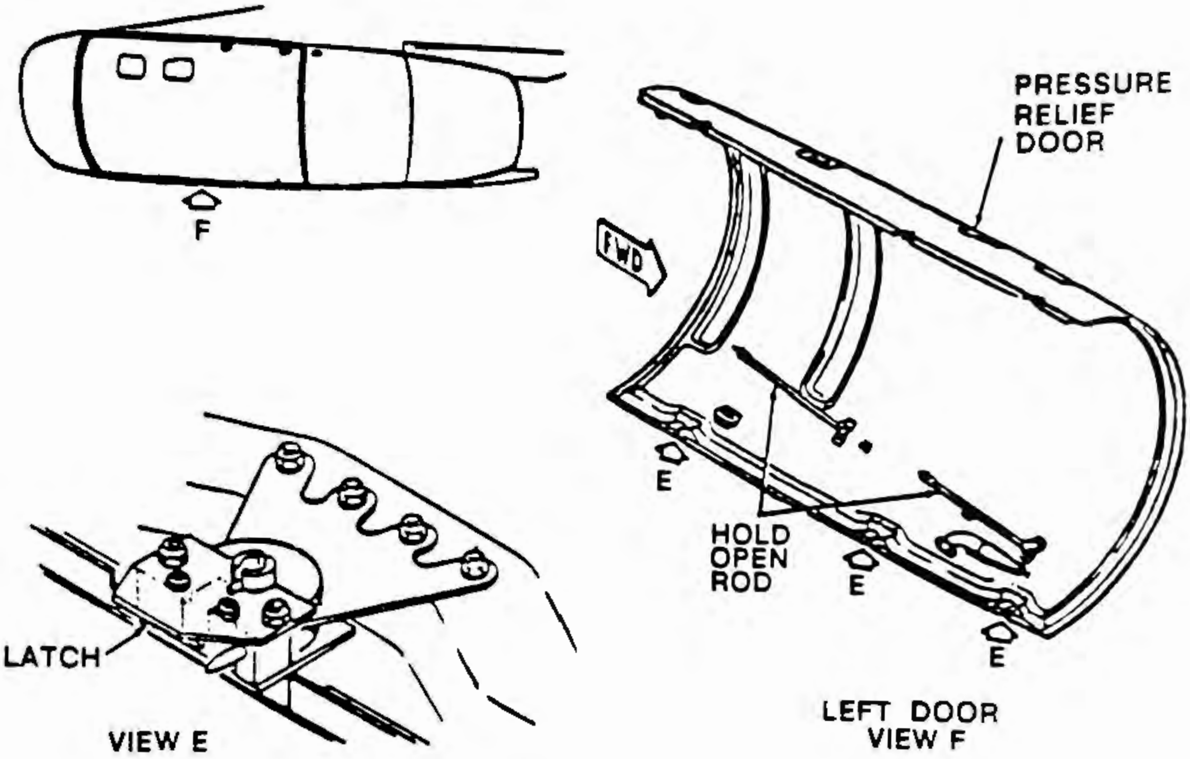
(1) The right and the left sections of the aft cowl complete the faired surface of the nacelle between the cowl doors and the thrust reverser translating ring. The upper edge of each section is connected to the pylon apron with screws. Both sections join at he bottom edge and are secured with two latch bolts.

(2) An access door for the forward latch bolt is located above the latch in the right section. The thrust reverser translating ring must be moved aft to gain access to the aft latch.



INLET BULLET

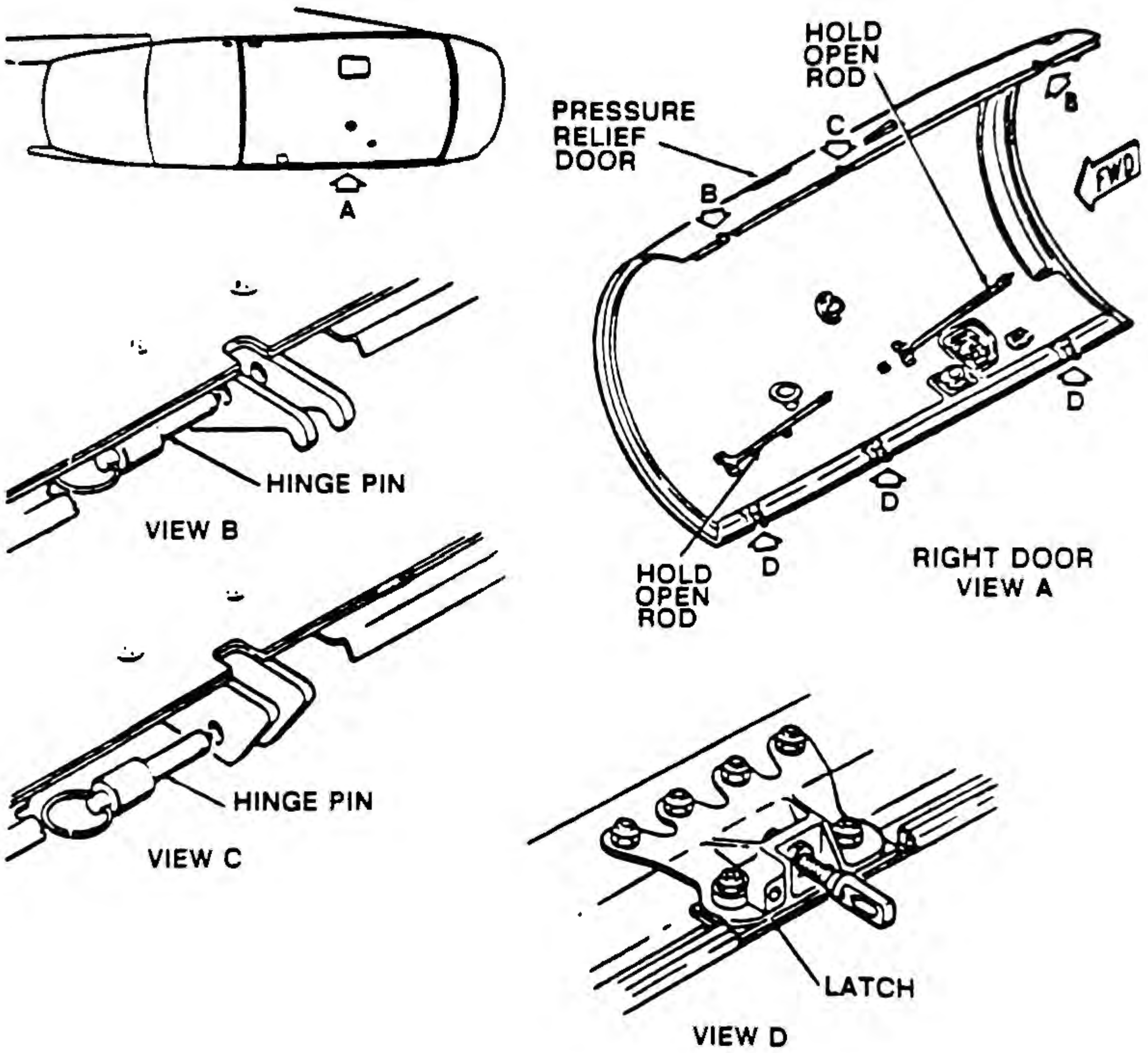
Figure 71-9



LEFT COWL DOOR - INSTALLATION

FTX80892

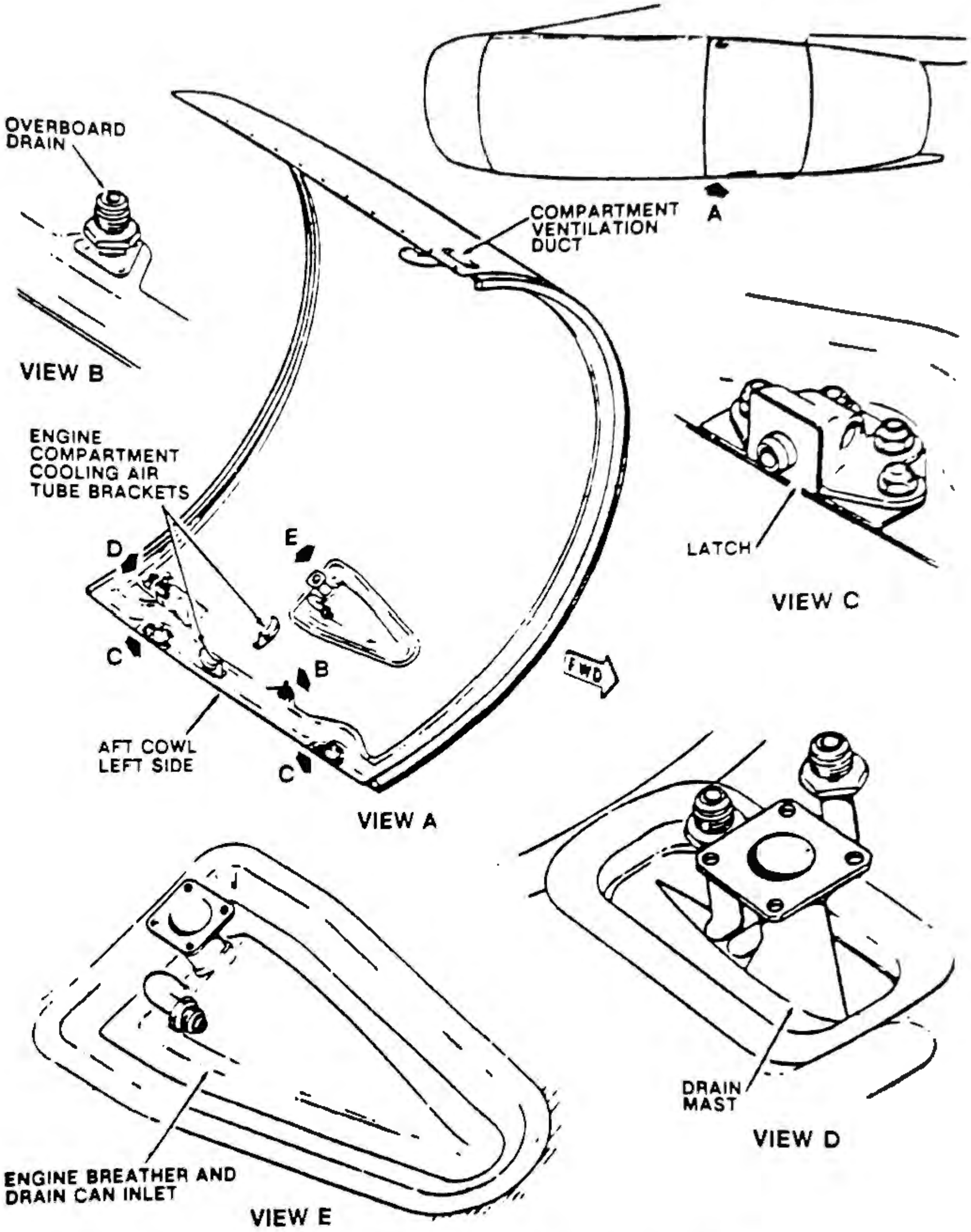
Figure 71-10



RIGHT COWL DOOR - INSTALLATION

FTX80893

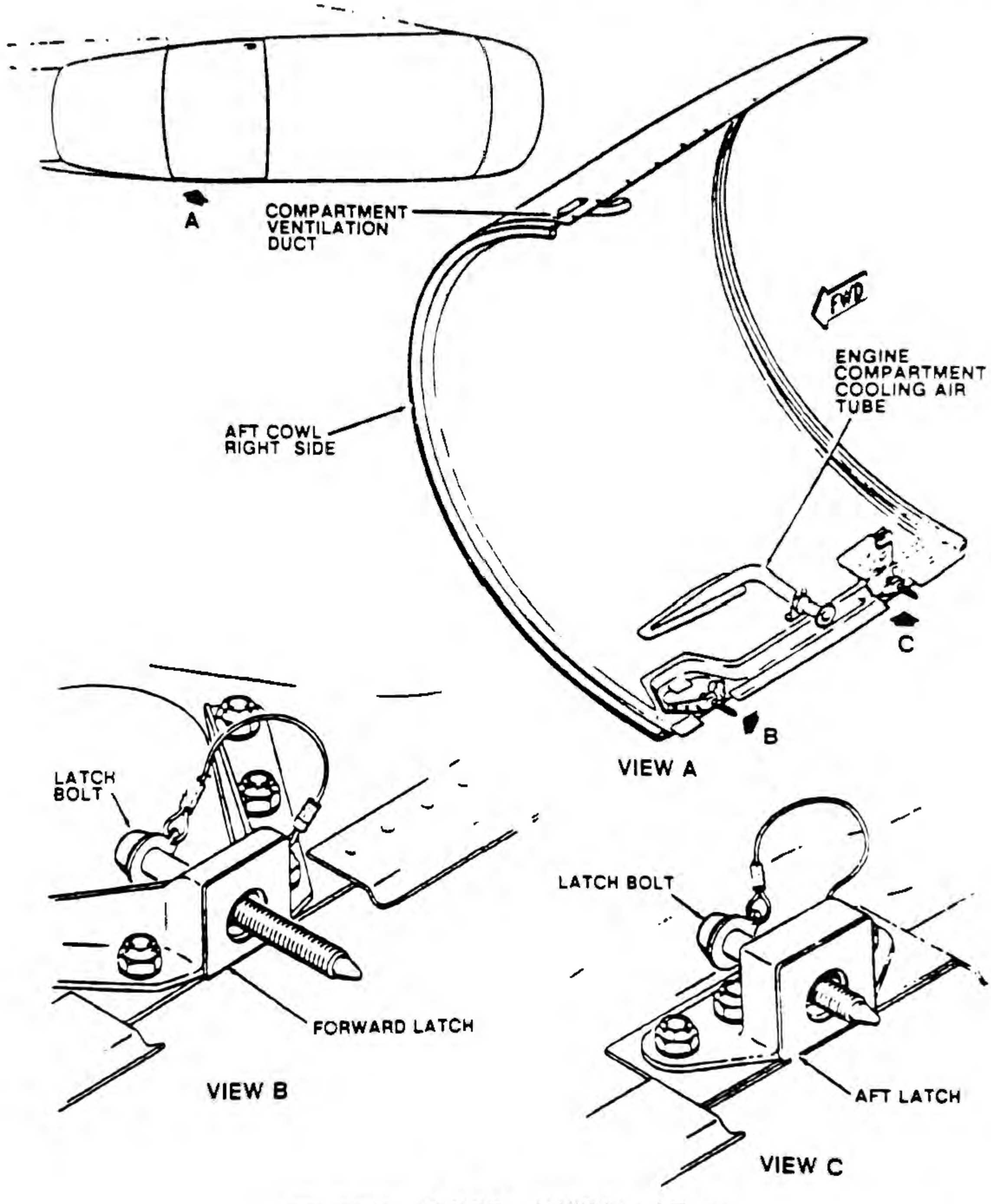
Figure 71-11


OVERBOARD DRAIN
VIEW B
COMPARTMENT VENTILATION DUCT
A
ENGINE COMPARTMENT COOLING AIR TUBE BRACKETS
D
E
C
B
FWD
AFT COWL LEFT SIDE
C
VIEW A
LATCH
VIEW C
DRAIN MAST
VIEW D
ENGINE BREATHER AND DRAIN CAN INLET
VIEW E

LEFT AFT COWL - INSTALLATION

FTX80894

Figure 71-12



AFT COWL DOOR - INSTALLATION

FTX80895

Figure 71-13

(2) An inlet duct in the right aft cowl provides cooling air for the engine compartment.

3. Mounts - Description and Operation

A. General (See Figure 72-14)

A three-point mounting system, consisting of two forward mounts and an aft mount, connects the engine to the pylon (see Figure 71-10). All three mounts compensate for engine case expansion and contraction. Side loads are normally transmitted to the pylon by the left forward mount and the aft mount. Thrust loads are normally transmitted to the pylon by the right forward mount. All three mounts transmit vertical loads to the pylon.

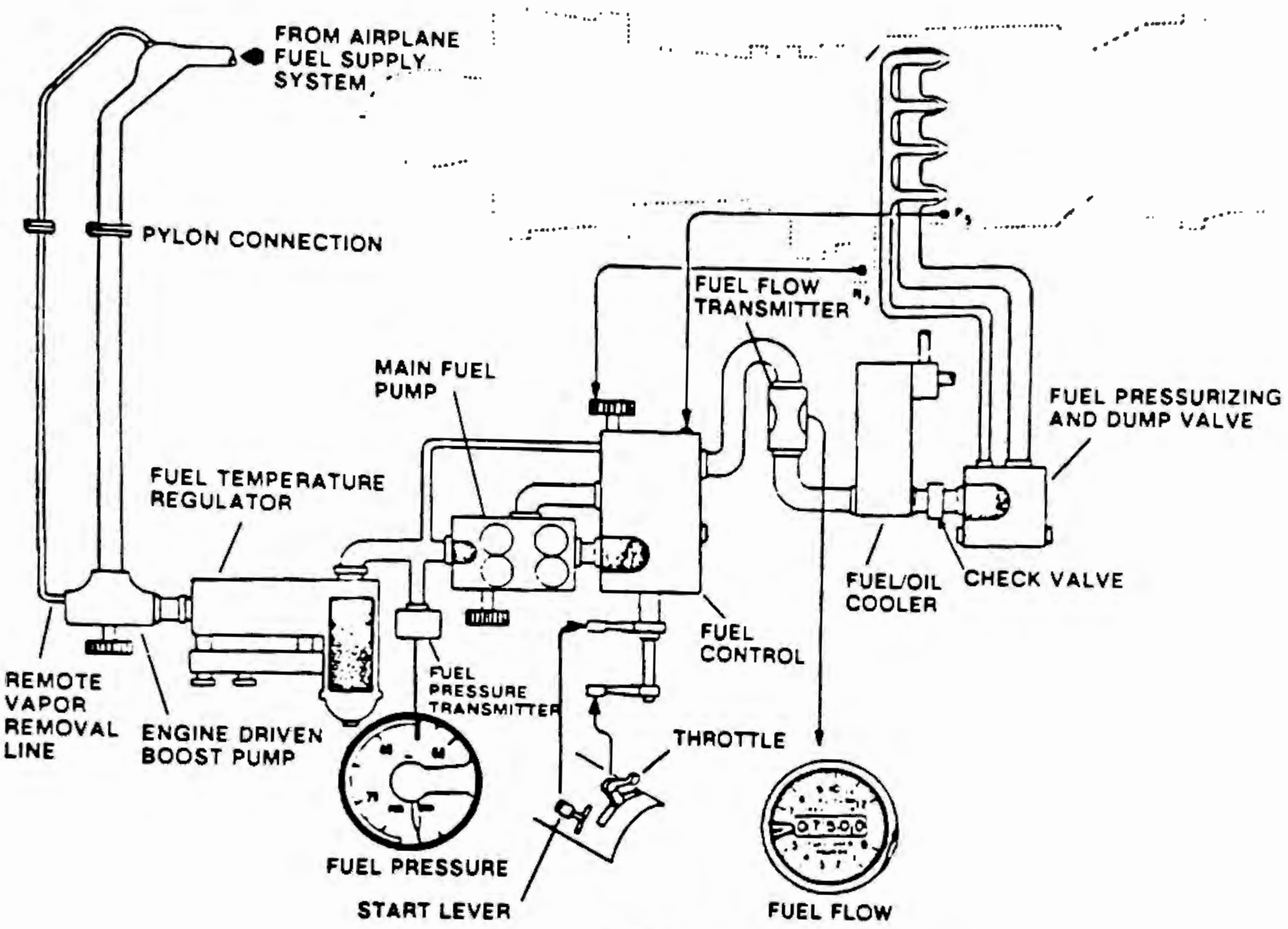
B. Forward Mounts (See Figures 71-15 and 71-16)

(1) The left mount consists of two A-shaped links, a brace, and a step bolt. These parts are attached to the left forward side of the engine, between the integral forward mount ring flanges, and to the pylon forward mount. When the powerplant is installed, the left mount step bolt is installed in the pylon forward mount and secured with a self-locking nut.

(2) The right mount consists of two A-shaped links, a brace, and a step bolt. These parts are attached to the right forward side of the engine, between the integral forward mount ring flanges, and to the pylon forward mount. When the powerplant is installed, the right mount step bolt is installed in the pylon forward mount and secured with a self-locking nut.

C. Aft Mount

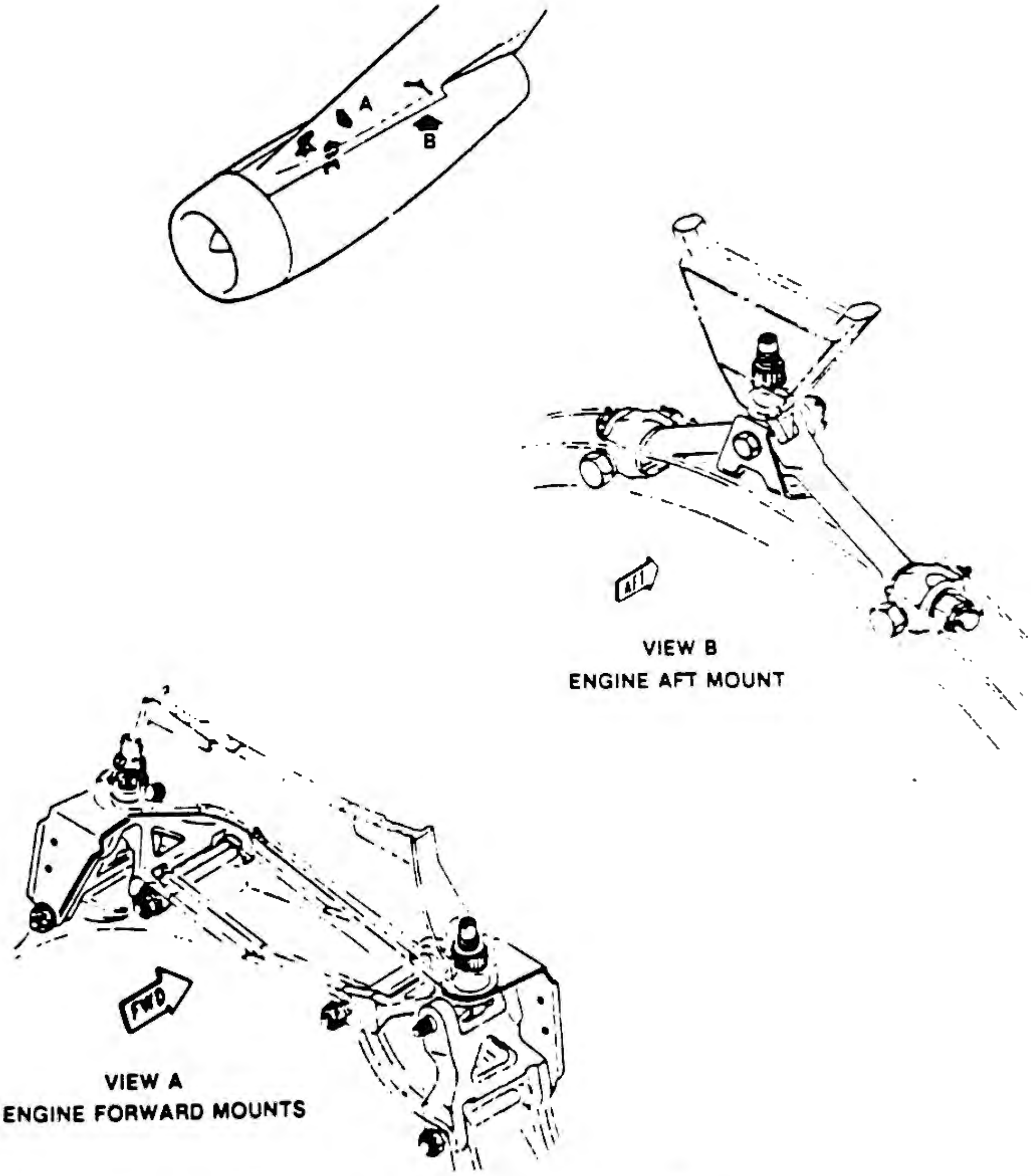
The aft mount consists of two arms, a step bolt, and a flange support. These parts are attached to the engine, between the integral aft mount ring flanges, and to the pylon aft mount link. When the powerplant is installed, the step bolt in the aft mount is installed in the pylon aft mount link and secured with a self-locking nut.



ENGINE FUEL SYSTEM SCHEMATIC

FTX80557

Figure 71-18



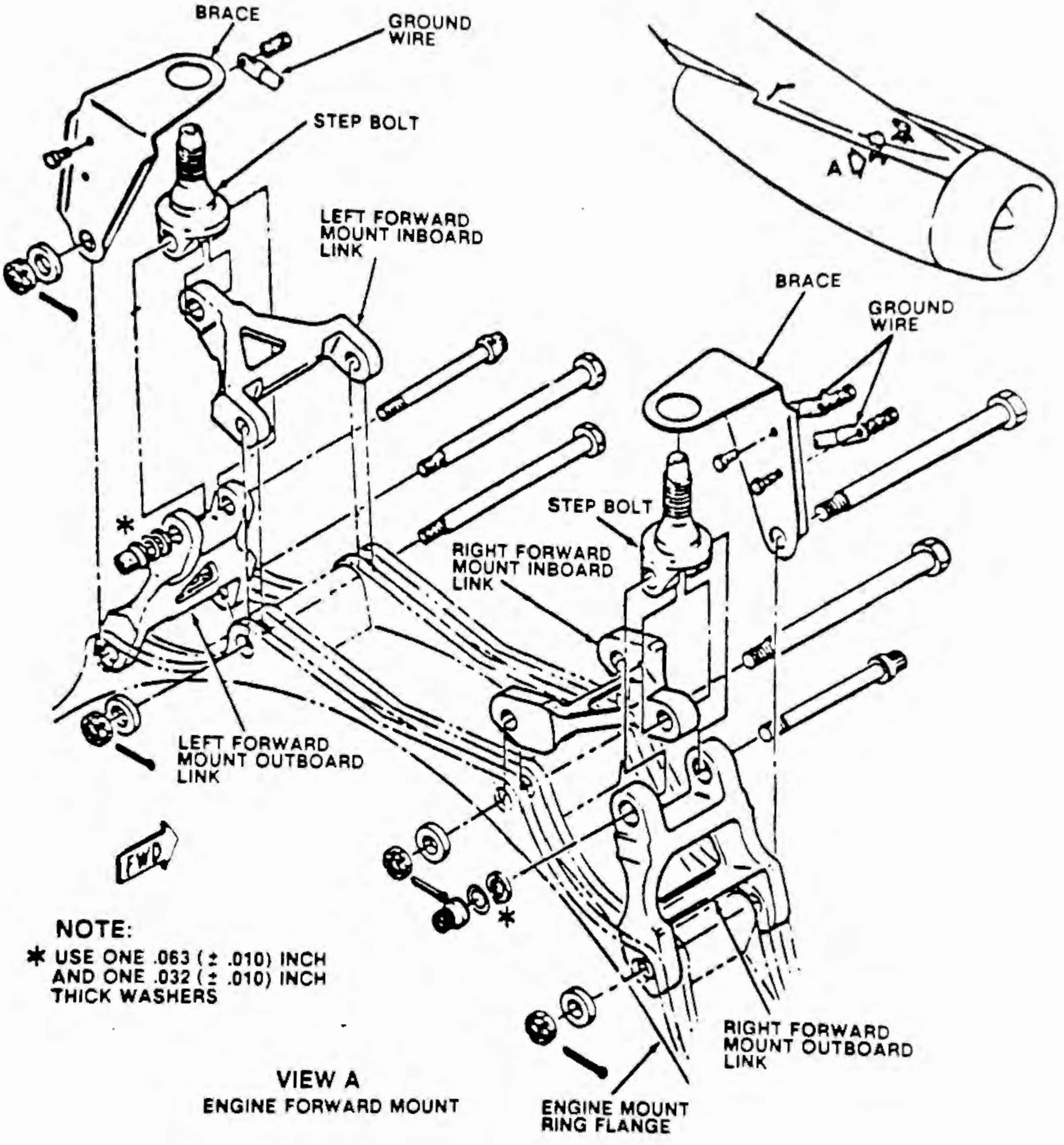
VIEW B
ENGINE AFT MOUNT

VIEW A
ENGINE FORWARD MOUNTS

MOUNTS--GENERAL LOCATION

FTX80555

Figure 71-14


BRACE
GROUND WIRE
STEP BOLT
LEFT FORWARD MOUNT INBOARD LINK
A
BRACE
GROUND WIRE
STEP BOLT
RIGHT FORWARD MOUNT INBOARD LINK
LEFT FORWARD MOUNT OUTBOARD LINK
FWD
RIGHT FORWARD MOUNT OUTBOARD LINK
ENGINE MOUNT RING FLANGE

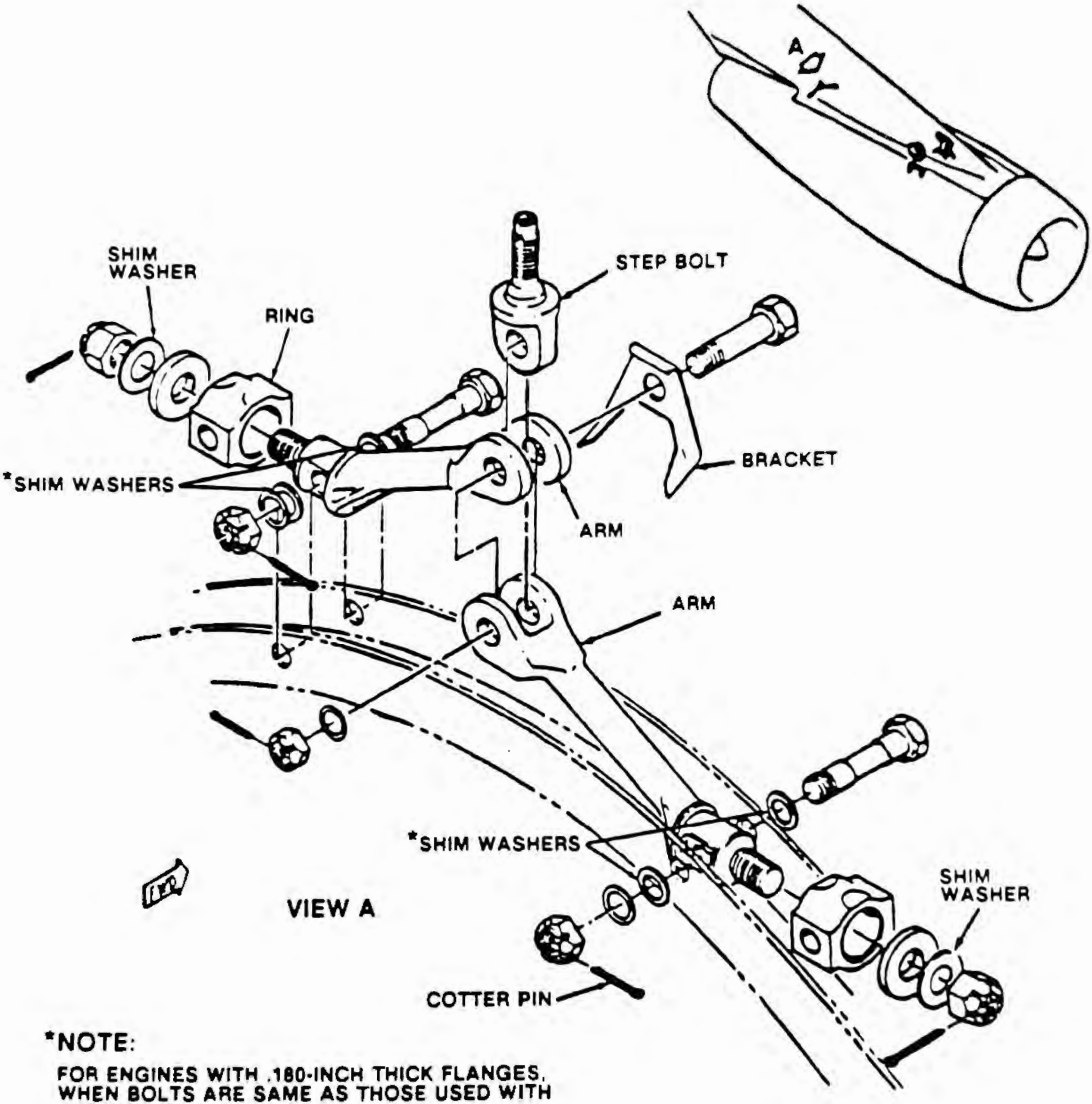
NOTE:
* USE ONE .063 (± .010) INCH AND ONE .032 (± .010) INCH THICK WASHERS

VIEW A
ENGINE FORWARD MOUNT

ENGINE FORWARD MOUNT - INSTALLATION RIGHT

FTX80896

Figure 71-15



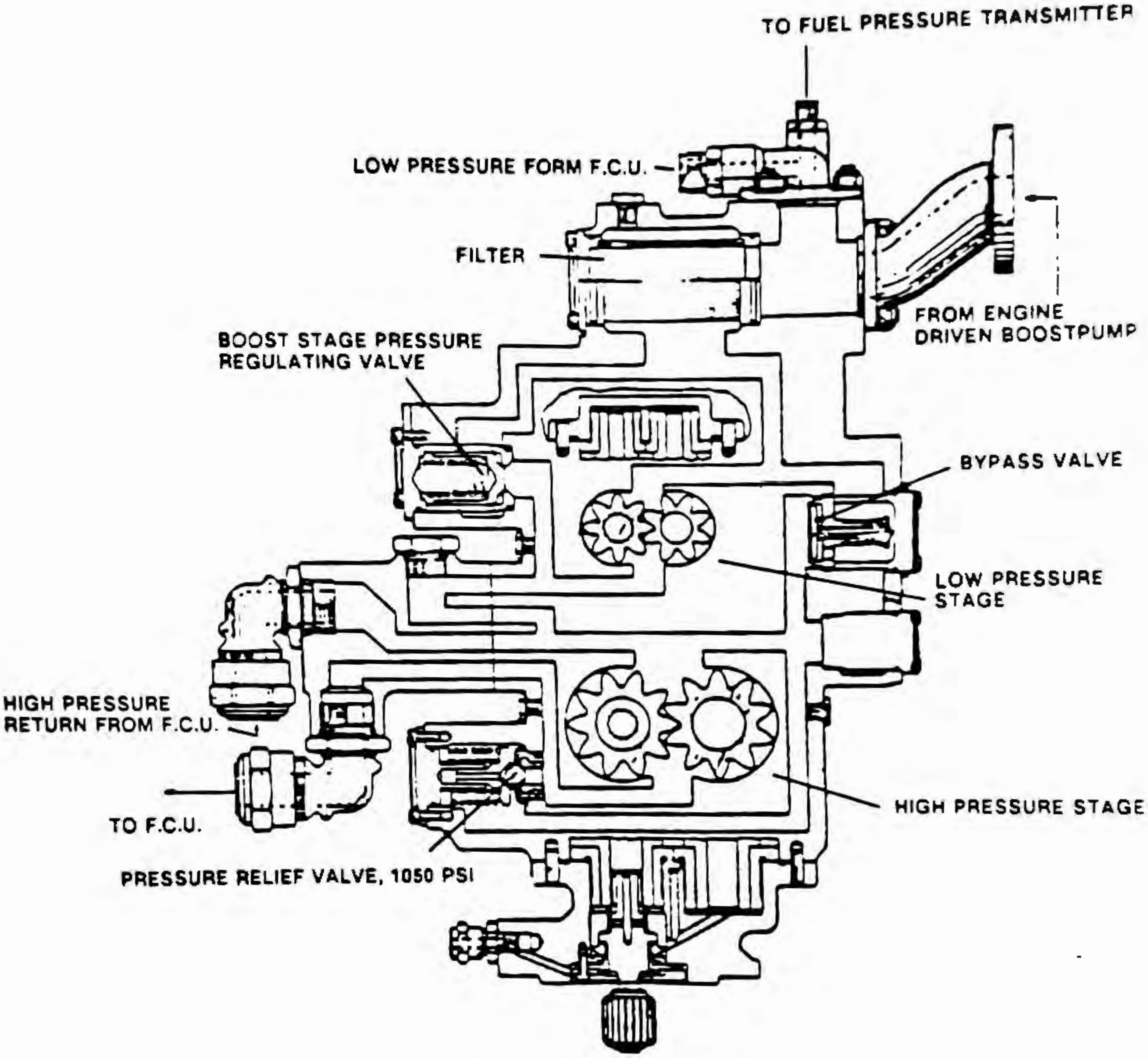
*NOTE:

FOR ENGINES WITH .180-INCH THICK FLANGES, WHEN BOLTS ARE SAME AS THOSE USED WITH .300-INCH THICK FLANGES

ENGINE REAR MOUNT - INSTALLATION

FTX80897

Figure 71-16


TO FUEL PRESSURE TRANSMITTER
LOW PRESSURE FORM F.C.U.
FILTER
FROM ENGINE DRIVEN BOOSTPUMP
BOOST STAGE PRESSURE REGULATING VALVE
BYPASS VALVE
LOW PRESSURE STAGE
HIGH PRESSURE RETURN FROM F.C.U.
TO F.C.U.
HIGH PRESSURE STAGE
PRESSURE RELIEF VALVE, 1050 PSI

MAIN FUEL PUMP

FTX80560

Figure 71-21

4. Fuel - Description and Operation

D. Description

The engine fuel distribution and control system consists of subsystems and components comprising an engine-driven fuel boost pump, engine-driven main fuel pump, fuel temperature regulator, engine-driven fuel control, pressurizing and dump valve, fuel shutoff valve, fuel tubes, fuel manifold and 48 individual fuel nozzles. This system ensures a clean, vapor-free supply of fuel to the engine under all operating conditions and power requirements. Indicating systems are provided to monitor engine fuel flow and fuel pressure with indicators mounted in the flight compartment.

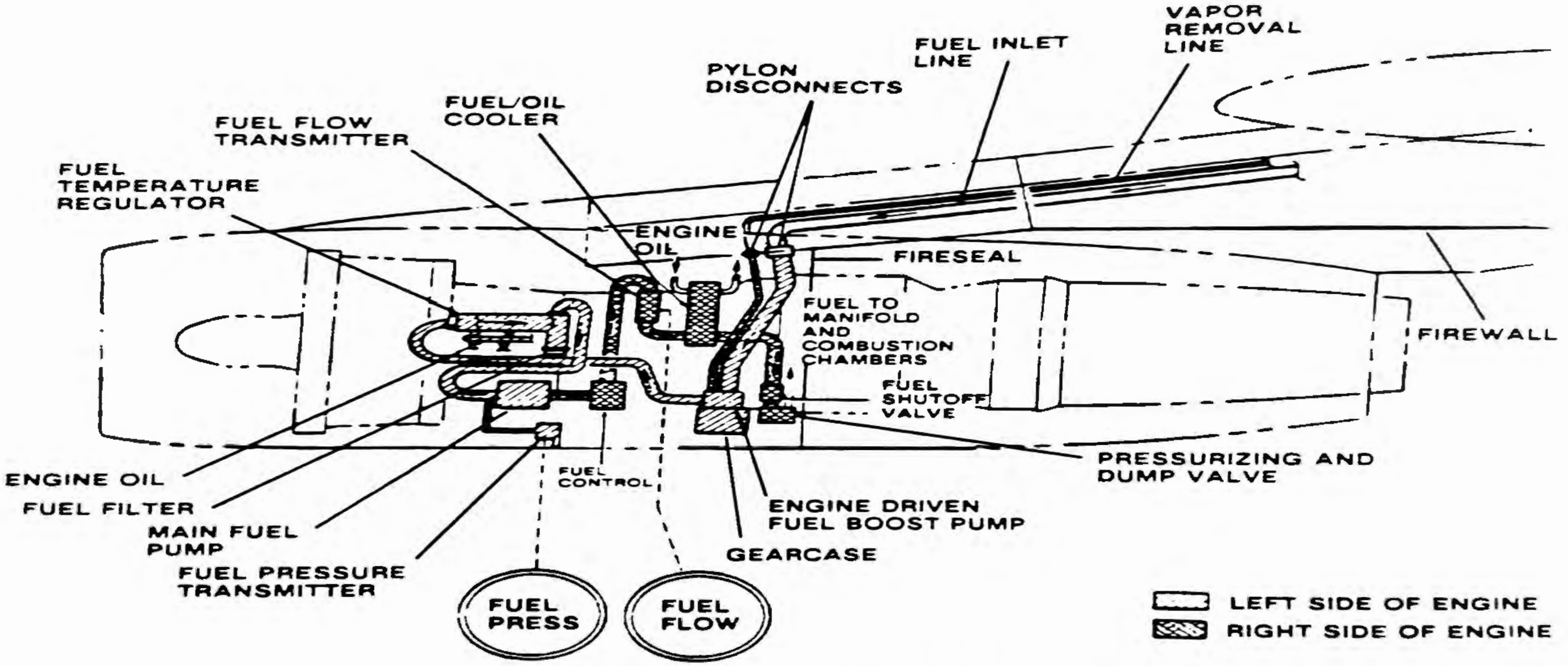
E. Operation

Fuel enters the fuel boost pump where the impeller separates the fuel vapor and air from the fuel, condensing much of the vapor to fuel; the remaining fuel vapor and air mixture is directed to a collecting groove near the impeller center, while the bubble-free fuel is delivered to the dischrge chamber. The first first stage liquid-ring compressor continuously withdraws the separated vapors and air from the collecting groove, pressurizes the vapors, absorbs the air, and discharges the fuel to the inlet of the compressor second stage centrifugal impeller. This impeller delivers the bubble-free fuel to the pump outlet. From the boost pump, fuel flows through the fuel temperature regulator to the main fuel pump where the pressure is increased and the fuel pumped to the fuel control. Fuel entering the fuel control is filtered, metered, and either directed through the fuel flowmeter, and fuel/oil cooler to the pressurizing and dump valve, or bypassed back to the inlet side of the main fuel pump. Fuel flow from the pressurizing and dump valve is discharged into the primary and secondary passages of the fuel manifold. Fuel entering the manifold is distributed through the 48 individual fuel nozzles into the combustion chambers.

4. Distribution - Description and Operation

A. General (See Figures 71-17 & 71-18)

(1) The fuel distribution system consists of the engine-driven fuel boost pump, fuel temperature regulator, engine-driven main fuel pump, fuel control unit, fuel flow transmitter, fuel/oil cooler, fuel shutoff valve, fuel tubes, fuel manifold and nozzles.



FUEL SYSTEM--SCHEMATIC

FTX80556

Figure 71-17

(2) The engine-driven fuel boost pump (see figures 71-19 & 71-20) is a single-stage centrifugal unit with a two-stage compressor. The compressor compresses fuel vapor and air to prevent its entry into the engine main fuel pump. The boost pump is provided with a bypass valve to minimize the pressure drop across the pump in the event of pump failure, and a discharge control valve to control pump discharge pressure. A separate vapor removal inlet port to the compressor allows the pump to withdraw fuel vapor and air from the high point of the engine pylon fuel line.

(3) The fuel temperature regulator is mounted on the forward underside of the engine.

(4) The engine-driven main fuel pump (see Figure 71-21) is mounted on the left forward side of the main accessory drive case. The two-stage gear pump incorporates an inlet fuel filter with a bypass valve, relief valve, check valve, and pressure regulating valve.

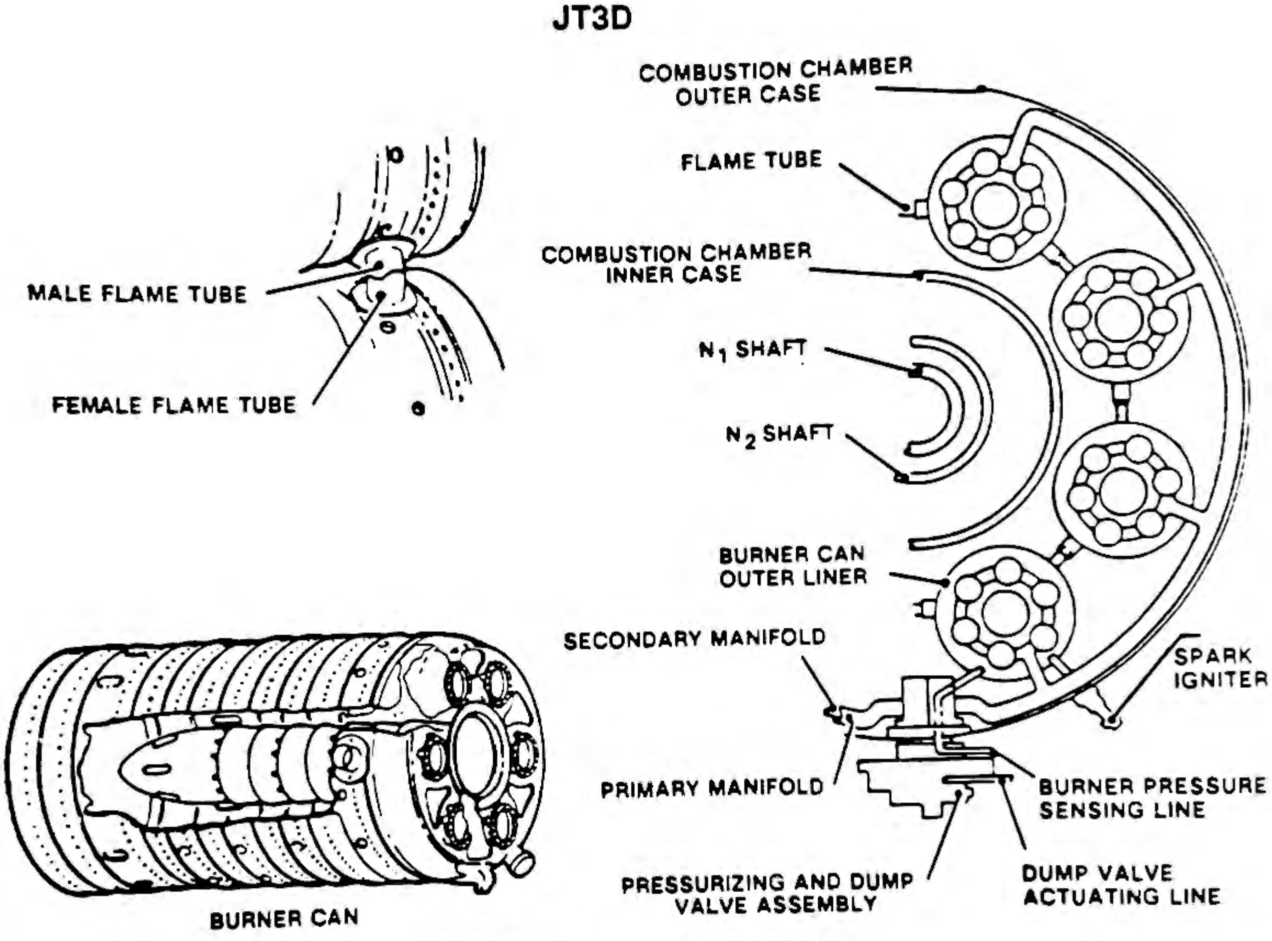
(5) The fuel control is mounted on the right forward side of the engine main accessory drive case.

(6) The fuel flow transmitter is installed in the fuel line between the fuel control and the fuel/oil cooler.

(7) The fuel/oil cooler is mounted on the right side of the engine adjacent to the fuel control.

(8) The fuel shutoff valve is installed in the fuel distribution system between the pressurizing and dump valve and the fuel line from the fuel/oil cooler. The valve shuts off the flow of fuel to the pressurizing and dump valve when the fuel pressure in the distribution system drops below the level required to unseat the spring-loaded piston in the shutoff valve.

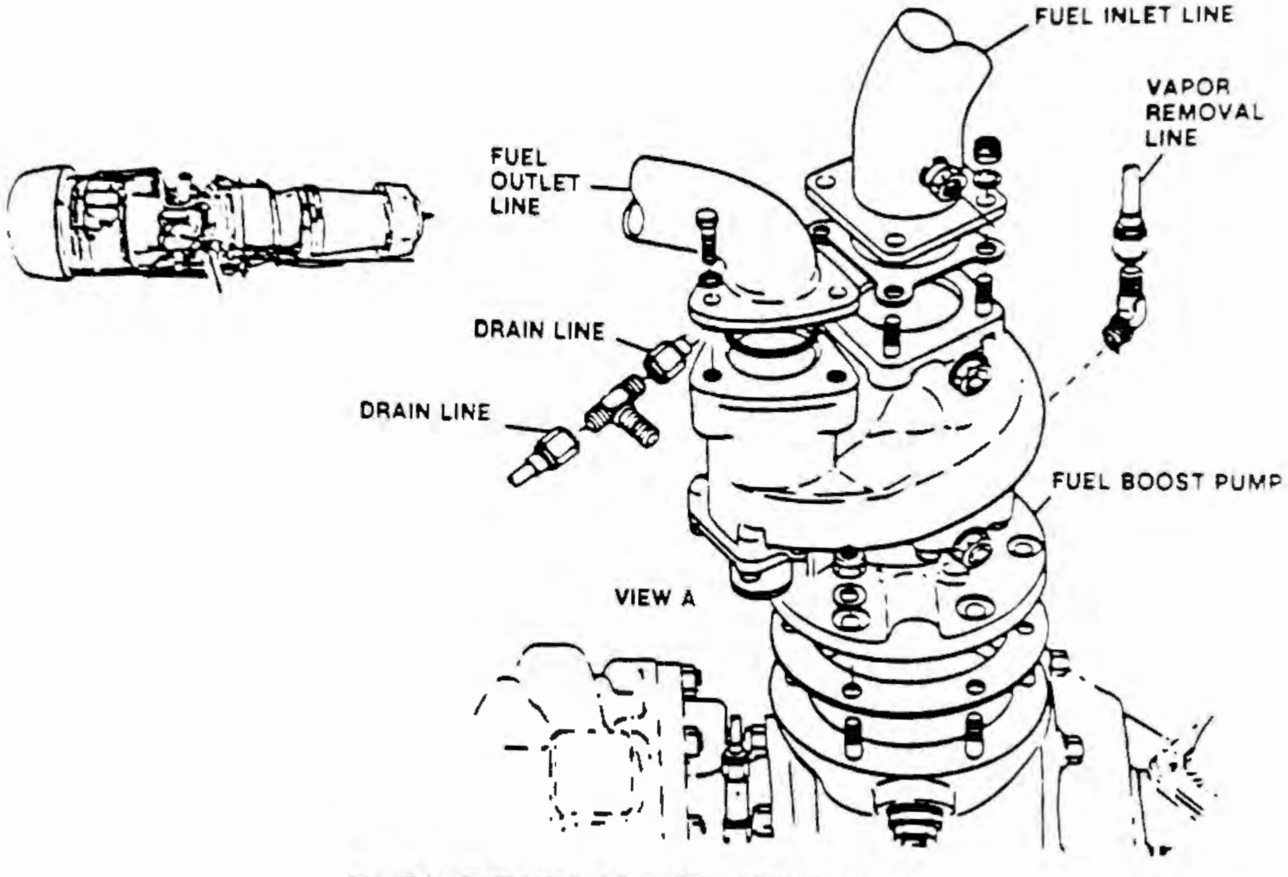
(9) The pressurizing and dump valve (see figures 71-22 & 71-23) is mounted on the bottom of the diffuser case. The valve consists of a 200-mesh fuel inlet screen, pressurizing valve, and dump valve. The pressurizing valve discharges fuel into the engine fuel manifold through the primary and secondary manifolds. The dump valve has been deactivated.


JT3D
COMBUSTION CHAMBER OUTER CASE
FLAME TUBE
COMBUSTION CHAMBER INNER CASE
MALE FLAME TUBE
FEMALE FLAME TUBE
N1 SHAFT
N2 SHAFT
BURNER CAN OUTER LINER
SECONDARY MANIFOLD
SPARK IGNITER
PRIMARY MANIFOLD
BURNER PRESSURE SENSING LINE
PRESSURIZING AND DUMP VALVE ASSEMBLY
DUMP VALVE ACTUATING LINE
BURNER CAN

COMBUSTION CHAMBER

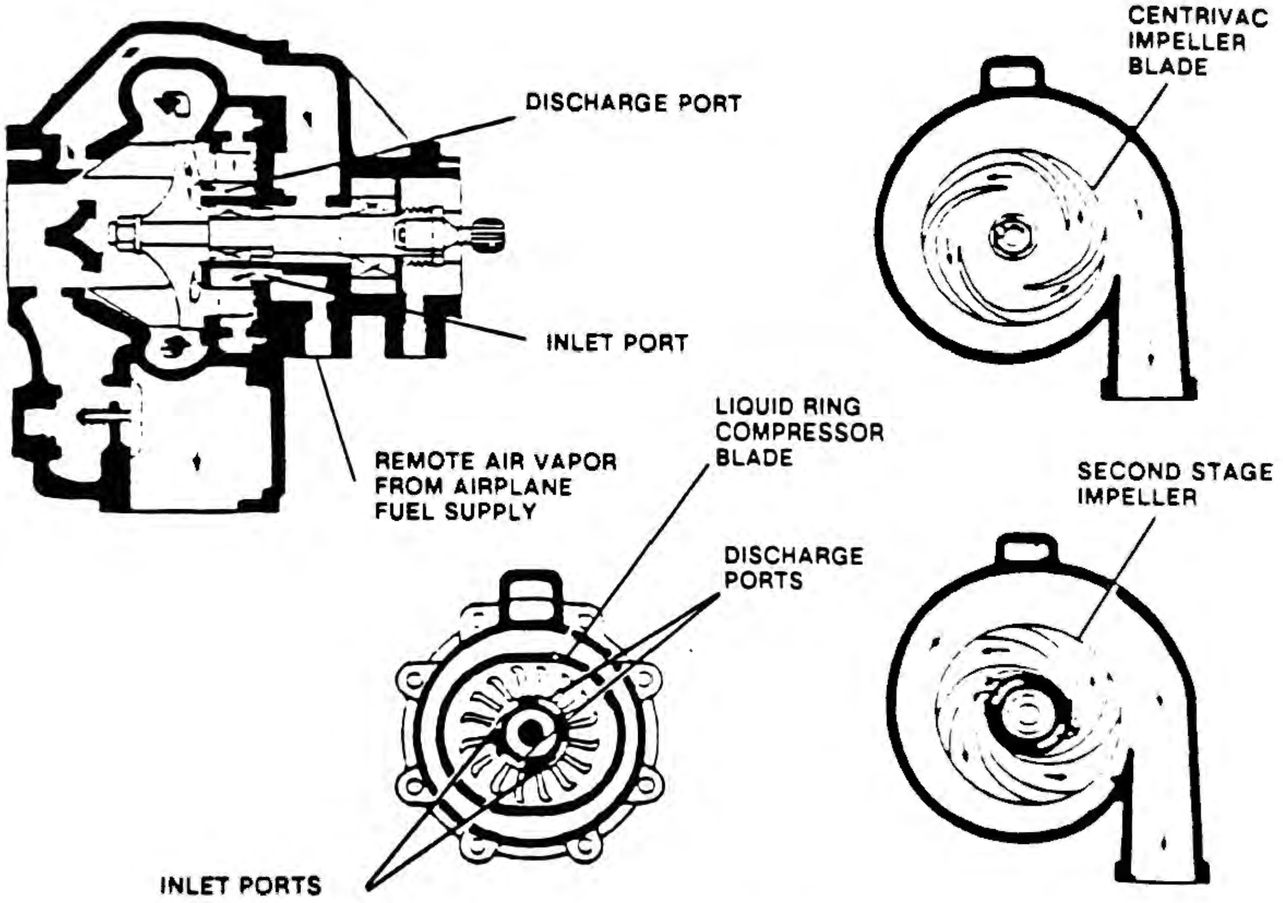
FTX80563

Figure 71-24



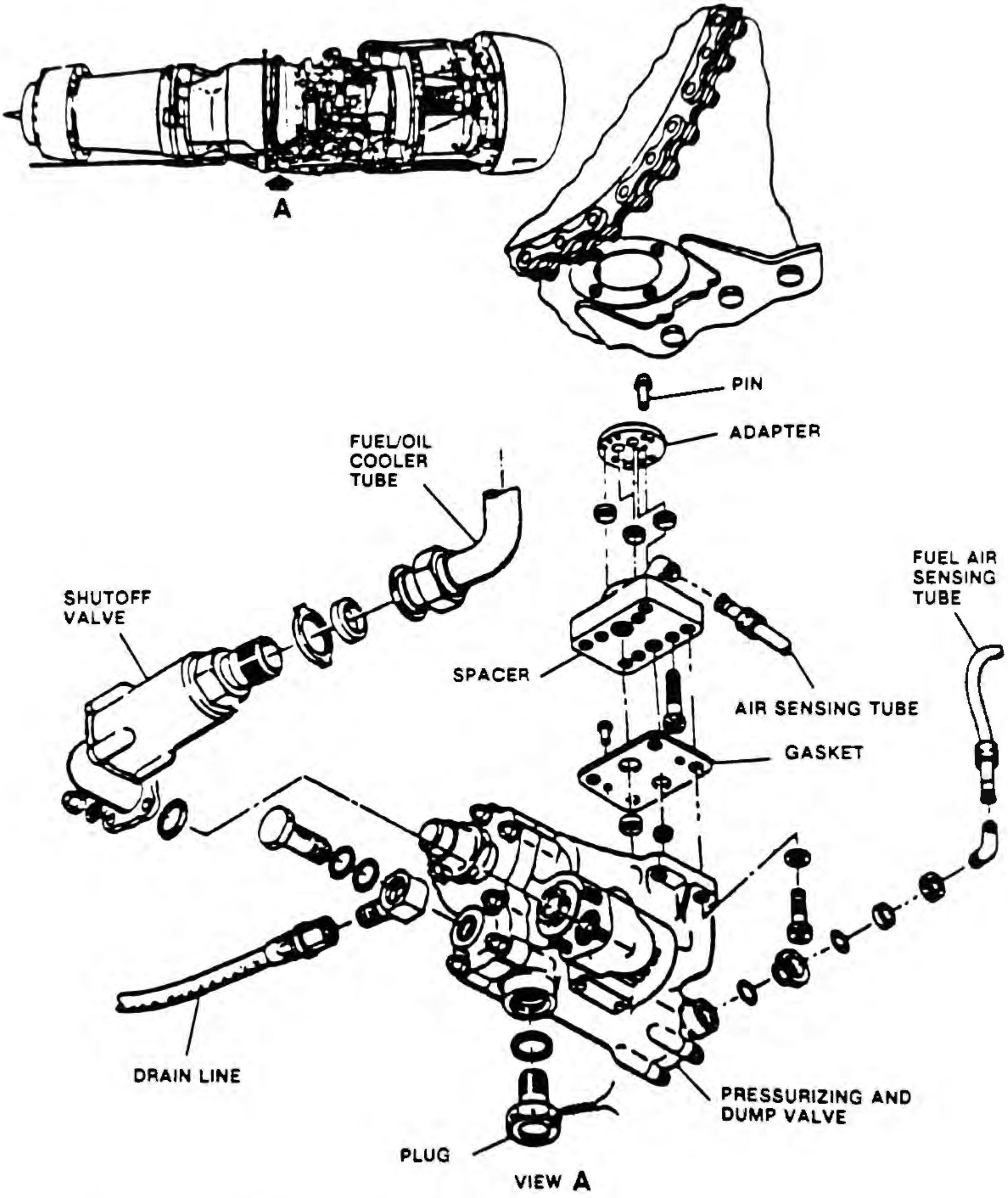
ENGINE-DRIVEN FUEL BOOST PUMP

Figure 71-19



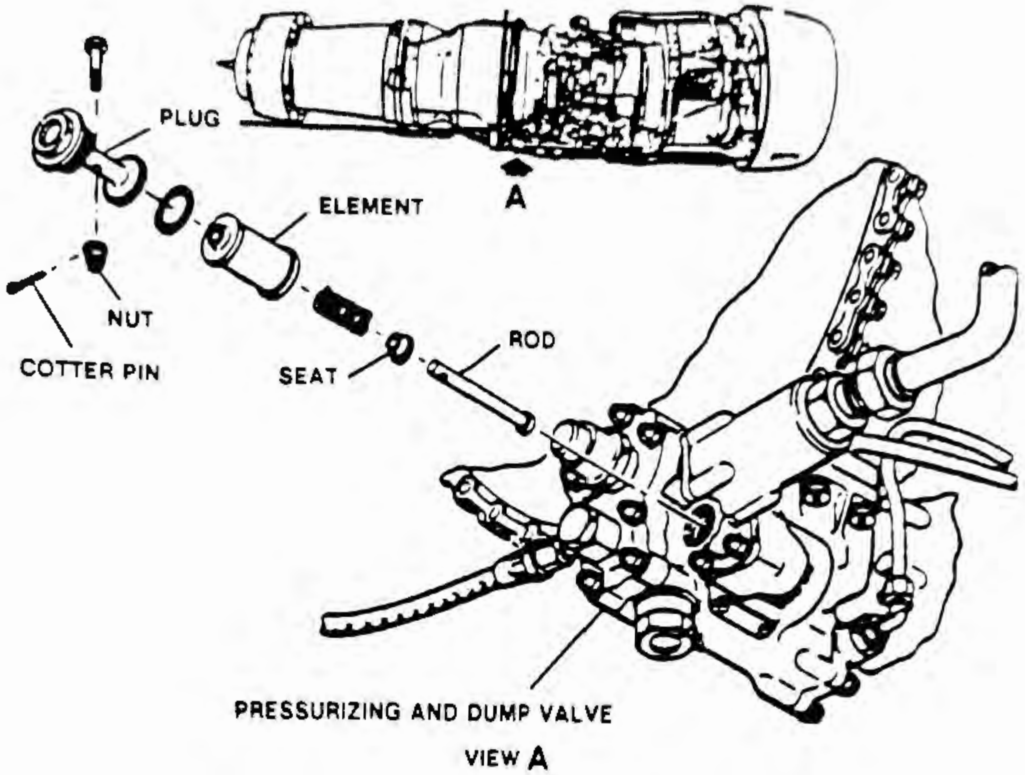
MULTIPHASE CENTRIVAC PUMP -- ENGINE DRIVEN BOOST FTX80559

Figure 71-20

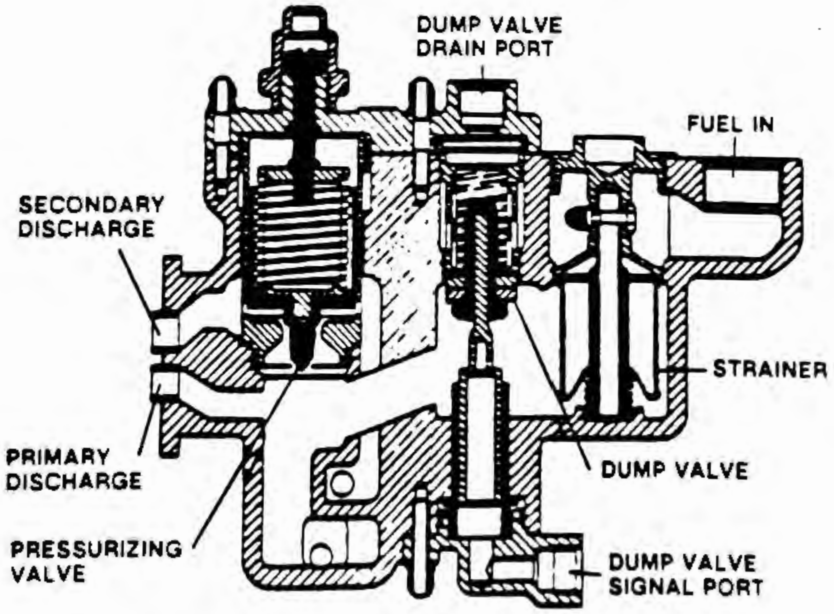


FUEL PRESSURIZING AND DUMP VALVE -- INSTALLATION FTX80561

Figure 71-22



STRAINER--INSTALLATION



FUEL PRESSURIZING AND DUMP VALVE FTX80562
Figure 71-23

9. Ignition - Description and Operation

A. Description (See Figure 71-27)

(1) The ignition system for each engine uses two high-energy, capacitor discharge ignition exciters to provide 20 joules of electrical energy for engine starting. Both of these exciters use 115-volt AC power supplied by an ignition circuit breaker, located on the main circuit breaker panel. In addition the exciters for engines 2 and 3, under certain selected conditions, may receive the required AC power from the ignition power supply.

(2) Each ignition system consists of a starter switch, an ignition selector switch, a start and ignition relay, a fuel shutoff lever ignition switch, an ignition override switch, two ignition exciters, two shielded high-tension igniter plug leads, and two igniter plugs. In addition, each ignition system for engines 2 and 3 includes an ignition power supply transfer relay. Common for these two engines is an ignition power supply switch, an ignition power supply control relay, and an ignition power supply.

(3) The ignition selector switch is located on the overhead switch panel in the flight compartment. The switch provides for the selection of exciter A, exciter B, or BOTH.

(4) The starter switch, one for each engine, is located on the overhead switch panel in the flight compartment. This switch is used for all engine starts from the 115-volt AC bus, and for starting engine 2 or 3 from the ignition power supply output.

(5) The start and ignition relay is located on the aft equipment panel. The relay contacts close when the starter switch is depressed, arming the fuel shutoff lever ignition switch with power from the 115-volt AC bus.

(6) The fuel shutoff lever ignition switch is located in the control pedestal, directly below the fuel shutoff lever. Forward movement of the fuel shutoff lever closes the switch contacts, completing the circuit from the 115-volt AC bus through the start and ignition relay contacts to the ignition exciters.

(10) Fuel tubes are external tubes which distribute fuel to the various engine fuel system components.

(11) The fuel manifold (see Figure 71-24) consists of two sections bolted to a common adapter in the diffuser case. Forty-eight fuel nozzle assemblies, arranged in eight clusters of six nozzles, are installed in the fuel manifold. Each cluster projects into accommodating apertures in the upstream end of each engine combustion chamber. Each fuel nozzle has two sets of metering slots and two sets of swirl chambers.

5. Fuel Temperature Regulator - Description and Operation

A. General (See Figure 71-25)

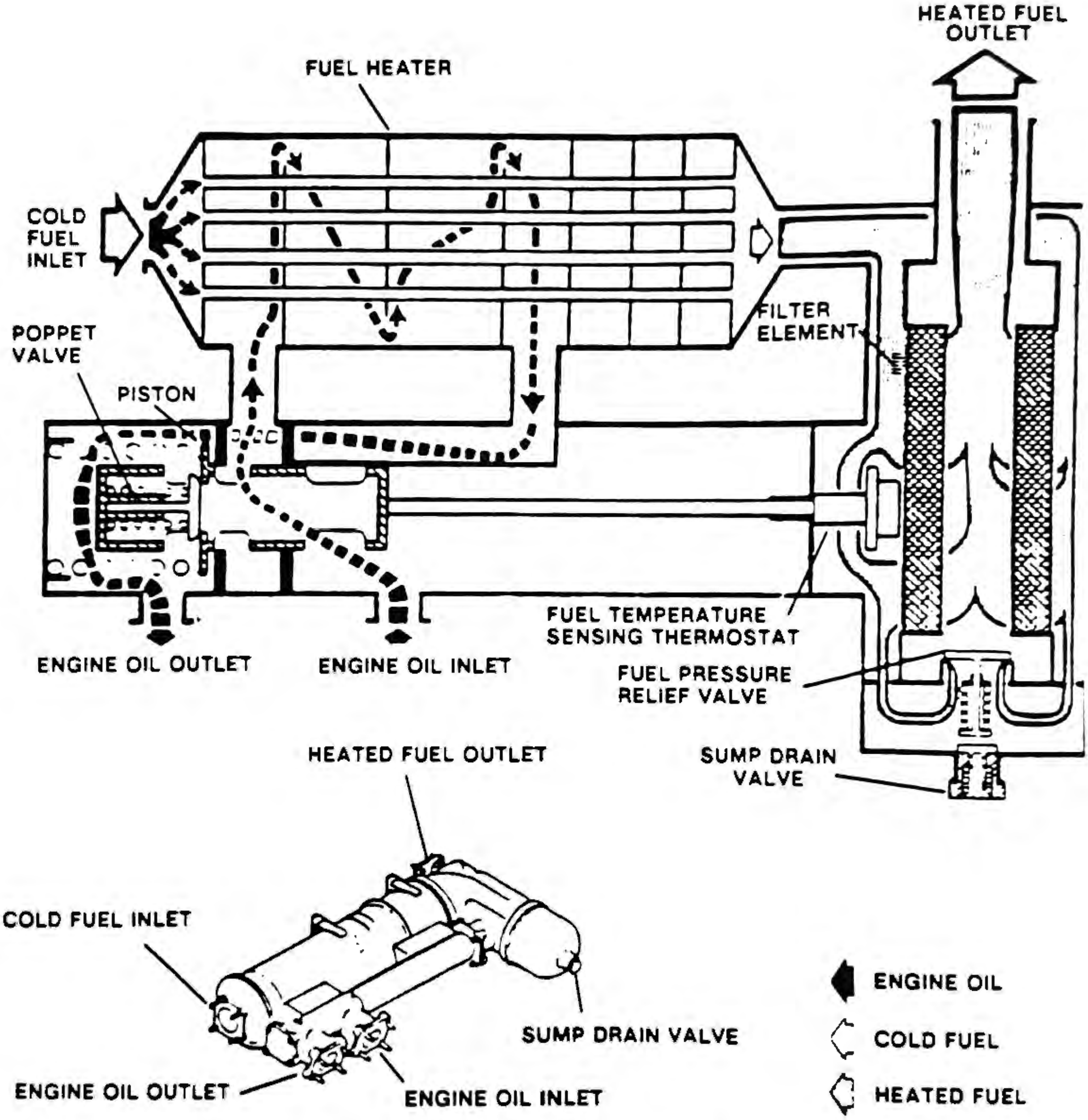
(1) The fuel temperature regulator is installed on the engine to heat the fuel to a uniform temperature, to cool the engine oil, and to filter the fuel.

(2) The regulator consists of a fuel/oil heat exchanger, a temperature controlled regulator valve, a filter, and a sump.

(3) Engine oil inlet and outlet ports are included in the regulator valve. Oil flow is regulated by a spring-loaded, temperature-controlled piston that channels engine oil either to the heat exchanger or to the outlet port.

(4) The fuel/oil heat exchanger is composed of a cylindrical housing, inlet and outlet ports for engine oil, heat transfer tubes, and fuel inlet and outlet manifolds. The heat transfer tubes pass through the engine oil compartment to connect the fuel inlet and outlet manifolds.

(5) The fuel filter assembly includes a filter, a spring-loaded fuel bypass valve, and a fuel temperature thermostat. A sump and drain assembly is installed on the filter housing, opposite the fuel outlet connection.



FUEL TEMPERATURE REGULATOR - SCHEMATIC FTX80563A

Figure 71-25

B. Operation

Fuel entering the fuel inlet manifold of the fuel temperature regulator is directed into the heat transfer tubes where it is heated by engine oil flowing around the tubes. The heated fuel passes out of the fuel outlet manifold into a filter where it is filtered and discharged through the fuel outlet connection. If fuel flow is restricted by a clogged filter element, the resulting pressure buildup causes the fuel bypass valve to open permitting the fuel flow to bypass the filter element. Fuel within the required temperature range or oil flow restriction in the temperature regulator causes the engine oil to bypass the temperature regulator.

6. Controlling - Description and Operation

A. General

(1) The fuel control consists of the metering and computing sections, which analyze various operational parameters and control the fuel flow to the engine. Fuel is metered according to a predetermined flow schedule which varies with power lever position, burner pressure (P_t4), and engine rpm. The fuel control includes a minimum pressure and shutoff valve, pressure regulating valve, speed sensing governor, throttle valve, burner pressure sensor assembly, ratio regulator assembly, main housing, auxiliary housing, main cover, a power lever, and a shutoff lever.

(2) A condensation trap in the pressure sensing line between the fuel control and the fuel pressurizing and dump valve provides for drainage of condensation.

7. Fuel Control - Description and Operation

A. General

(1) The fuel control is designed to control the engine under all operating conditions. Two control levers are provided; one a power lever, the other a shutoff lever. The power lever controls engine speed during all forward or reverse thrust operations. The shutoff lever controls engine starting and shutdown by opening or closing a fuel shutoff valve.

(2) The fuel control accurately governs the engine steady state selected speed, acceleration, deceleration, maximum burner pressure, and provides a number of auxiliary signals. The speed governing system is of the proportional or droop type.

(3) The fuel control consists of a metering and a computing section. The metering section selects the flow rate of fuel to be supplied to the engine burners to provide the required engine thrust output, subject to engine operating limitations as sensed and scheduled by the fuel control computing section.

(4) The fuel control has a coarse and a fine filter. The coarse or main filter protects the metering section against damage by fuel contaminants. A bypass valve permits continued flow of fuel when the filter is clogged. The fine filter protects the computing section against damage by fuel contaminants. This filter is cleaned by the washing action of the fuel flow to the metering section.

8. Indicating - Description and Operation

A. General

Indicating systems are provided to monitor the engine fuel flow rate and pressure.

B. Fuel Flow Indicating System

(1) The engine fuel flow indicating system provides a visual indication of engine fuel flow rate. The system consists of a transmitter, installed in the fuel line between the fuel control and the fuel/oil cooler, and an indicator mounted on the instrument panel in the flight compartment. The system is supplied with 115 VAC through a circuit breaker located on the main circuit breaker panel.

(2) The fuel flow transmitter measures the flow rate of fuel consumed by the engine and provides a start and stop pulse output that is proportional to the measured mass fuel flow. The transmitter consists of a spring assembly, a swirl cap, rotor and magnet assembly that creates the start pulse, and a spring restrained turbine that creates the stop pulse. The fuel flow transmitter requires no electrical power for its operation.

(3) The fuel flow indicator provides visual indication of flow rate by an analog pointer, and a four-digit dichroic liquid crystal display of fuel used. The indicator range is from 0 to 12,000 PPH and is divided into 250 PPH increments. The fuel used is displayed from 0 to 99,990 pounds in 10 pound increments. The indicator includes an electrical reset of fuel used.

C. Fuel Pressure Indicating System (See Figure 71-26)

(1) The fuel pressure indicating system consists of a pressure transmitter mounted on the engine and an indicator mounted on the instrument panel in the flight compartment. The system is supplied with 28 VAC through a circuit breaker on instrument secondary bus 2 and 3.

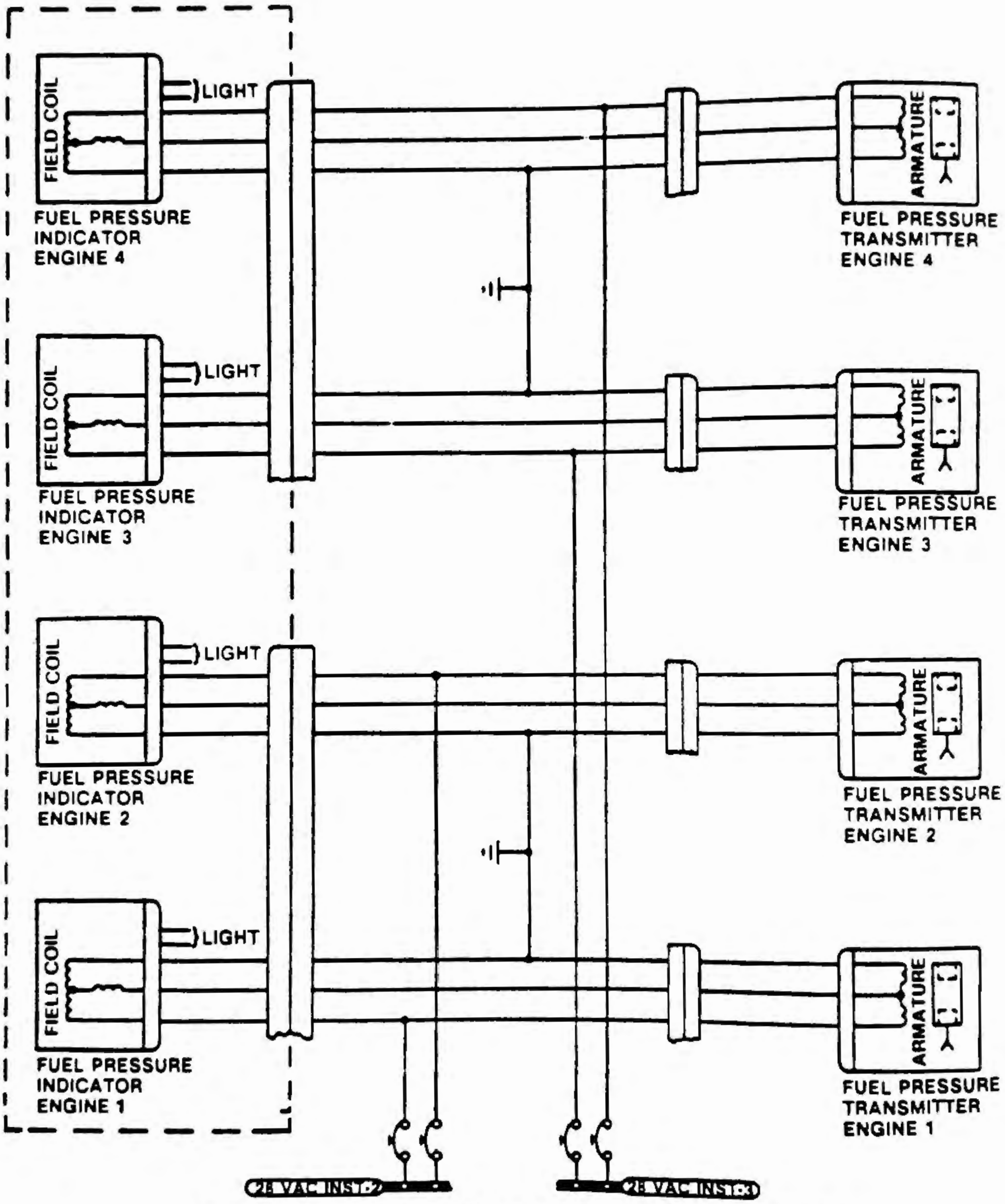
(2) The fuel pressure transmitter consists of a diaphragm and a magnetic armature inside two stationary coils. The components are enclosed in a housing provided with a pressure sensing port, vent port, and an electrical connector.

(3) The fuel pressure indicator is integrally lighted and hermetically sealed.

D. Operation

(1) A start and stop pulse from the fuel flow transmitter is fed to the fuel flow indicator micro processor. The fuel flow indicator processes the start and stop pulse and calculates the flow rate, then, using a crystal timebase, integrates the rate to derive fuel used.

(2) The fixed coils in the fuel pressure transmitter and indicator are interconnected by three unshielded wires to form an AC bridge. With the pressure applied to the transmitter unchanged, the bridge is electrically balanced and no current flows through the moving coil of the indicator. When pressure increases or decreases, the diaphragm in the transmitter moves the armature, thus changing the reluctance of the transmitter coils and unbalancing the bridge. This unbalance results in a current flow and accompanying torque in the movable coil of the indicator. The coil with its attached pointer turns until the torque is zero and the bridge is again balanced. Dial markings on the indicator show the position assumed by the pointer for the various applied pressures.


FIELD COIL
LIGHT
FUEL PRESSURE INDICATOR ENGINE 4
FIELD COIL
LIGHT
FUEL PRESSURE INDICATOR ENGINE 3
FIELD COIL
LIGHT
FUEL PRESSURE INDICATOR ENGINE 2
FIELD COIL
LIGHT
FUEL PRESSURE INDICATOR ENGINE 1
ARMATURE
FUEL PRESSURE TRANSMITTER ENGINE 4
ARMATURE
FUEL PRESSURE TRANSMITTER ENGINE 3
ARMATURE
FUEL PRESSURE TRANSMITTER ENGINE 2
ARMATURE
FUEL PRESSURE TRANSMITTER ENGINE 1
28 VAC INST 2
28 VAC INST 3

ENGINE FUEL PRESSURE INDICATING SYSTEM
SCHEMATIC

FTX80564

Figure 71-26

(3) Ignition override is obtained by placing the ignition override switch in the on position. This completes a circuit from the 115-volt AC bus to the contacts of the ignition selector switch for the outboard engines, or a circuit from the 115-volt AC bus through the contacts of the ignition power supply transfer relays to the contacts of the ignition selector switch for the inboard engines. Both exciters are activated simultaneously or separately, depending upon the position of the ignition selector switch, and will produce ignition continuously until the ignition override switch is returned to the off position.

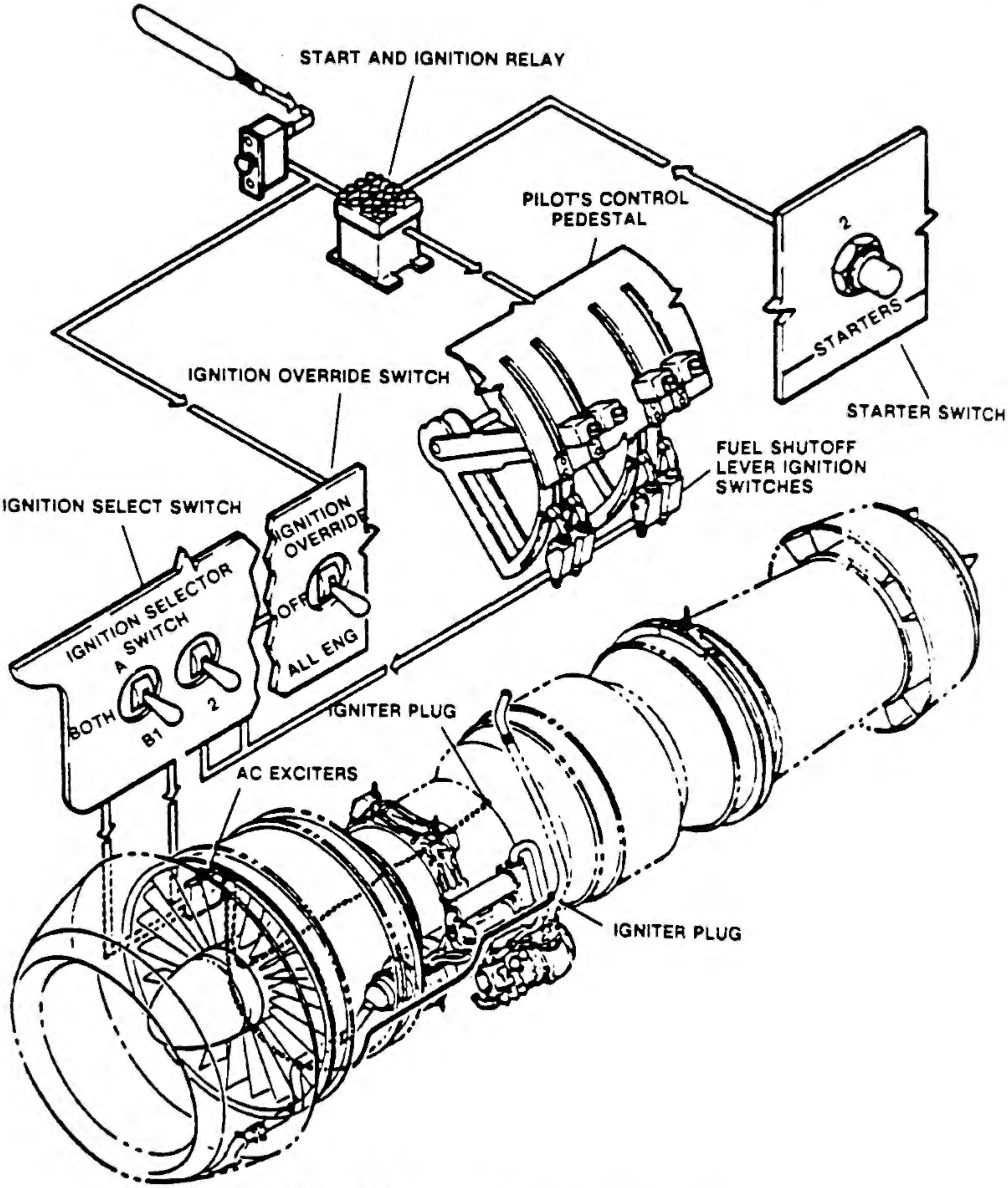
10. Distribution - Description and Operation

A. General (See Figure 71-30)

(1) The ignition distribution system provides a means for conducting engine ignition voltage. The system consists of two shielded high tension leads and two igniter plugs. The tension leads are connected between the ignition exciters and the igniter plugs.

(2) The two high tension leads each consist of an electrical cable encased in a braided conduit with an electrical connector at each end. The leads and connectors are shielded to prevent radio interference. One high tension lead attaches to the aft end of exciter A and the other to the aft end of exciter B. The lead from exciter B crosses under the engine and is connected to the igniter plug in combustion chamber 5. The lead from exciter A extends aft along the lower right side of the engine and is connected to the igniter plug in combustion chamber 4.

(3) Two igniter plugs are provided, one in combustion chamber 4 and the other in combustion chamber 5. The igniter plugs pass through holes in the lower portion of the diffuser case. Each igniter plug consists of a center electrode encased in an insulator, which is in turn covered by a metal shell.



ENGINE IGNITION SYSTEM - FUNCTIONAL DIAGRAM FTX80565

Figure 71-27

(7) The ignition override switch is located on the overhead switch panel. This switch bypasses the start and ignition relay contacts and the fuel shutoff lever ignition switch to permit the energizing of the ignition system during takeoff and landing or during flight, and to initiate a relight or to prevent engine flameout under adverse weather or other operation conditions.

(8) Two 20-joule AC ignition exciters are located on the right forward side of the engine. The exciters convert the 115-volt AC to high potential electrical energy for engine starting.

(9) Two shielded high-tension igniter plug leads are utilized between each of the exciter output connections and the igniter plugs. One lead connects to igniter plug A, installed in combustion chamber No. 4, and the other lead connects to igniter plug B, installed in combustion chamber No. 5.

(10) The ignition power supply transfer relays, one each for engines 2 and 3, are located on the aft equipment panel. When either 115-volt AC bus No. 2 or No. 3 is energized, the respective transfer relay coil is activated. This causes the normally open contacts of the relay to close, connecting the 115-volt AC bus to the ignition circuit to arm both the start and ignition relay contacts and the ignition override switch. When the AC buses are not energized, the normally closed portion of the same set of contacts completes the circuit from the ignition power supply to the start and ignition relay contacts and to the ignition override switch. The second set of normally closed contacts of the ignition power supply transfer relay completes the circuit between the ignition power supply switch and the ignition power supply control relay coil.

(11) The ignition power supply switch is located on the flight engineer's instrument panel in the flight compartment. The switch, when placed in the arm position, energizes the coil of the ignition power supply control relay, provided neither 115-volt AC bus No. 2 or bus No. 3 is energized.

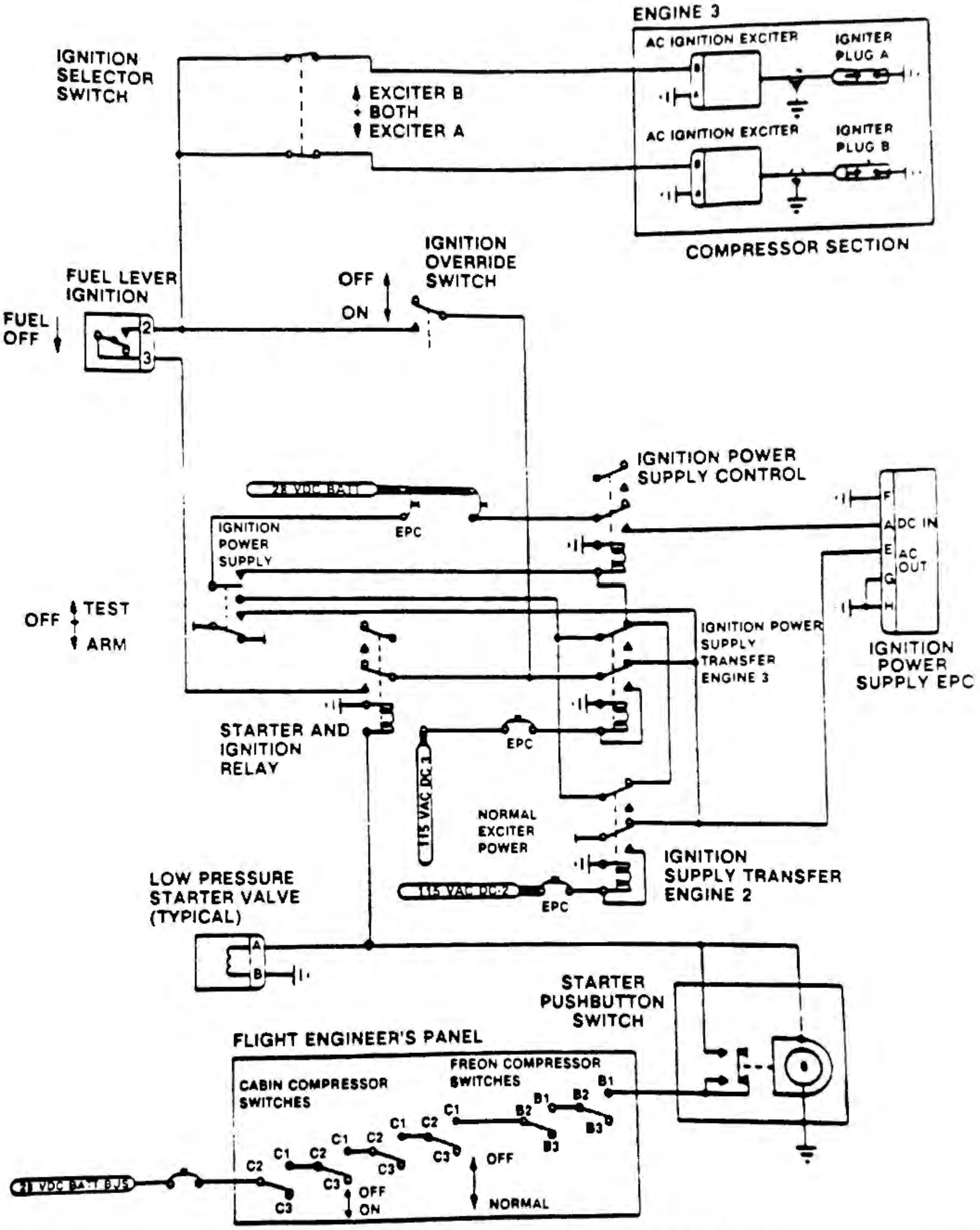
(12) The ignition power supply control relay is located on the aft equipment panel. The relay is energized by the 28-volt DC battery bus through the contacts of the ignition power supply switch (see step 11).

(13) The ignition power supply is located in the electrical power center, immediately above the generator control panels, and is used to convert DC power from the battery bus to AC power of the proper magnitude for energizing the ignition exciters. The 28-volt DC is supplied to the ignition power supply through the contacts of the ignition power supply control relay when the relay coil is energized.

B. Operation (See Figures 71-28 & 71-29)

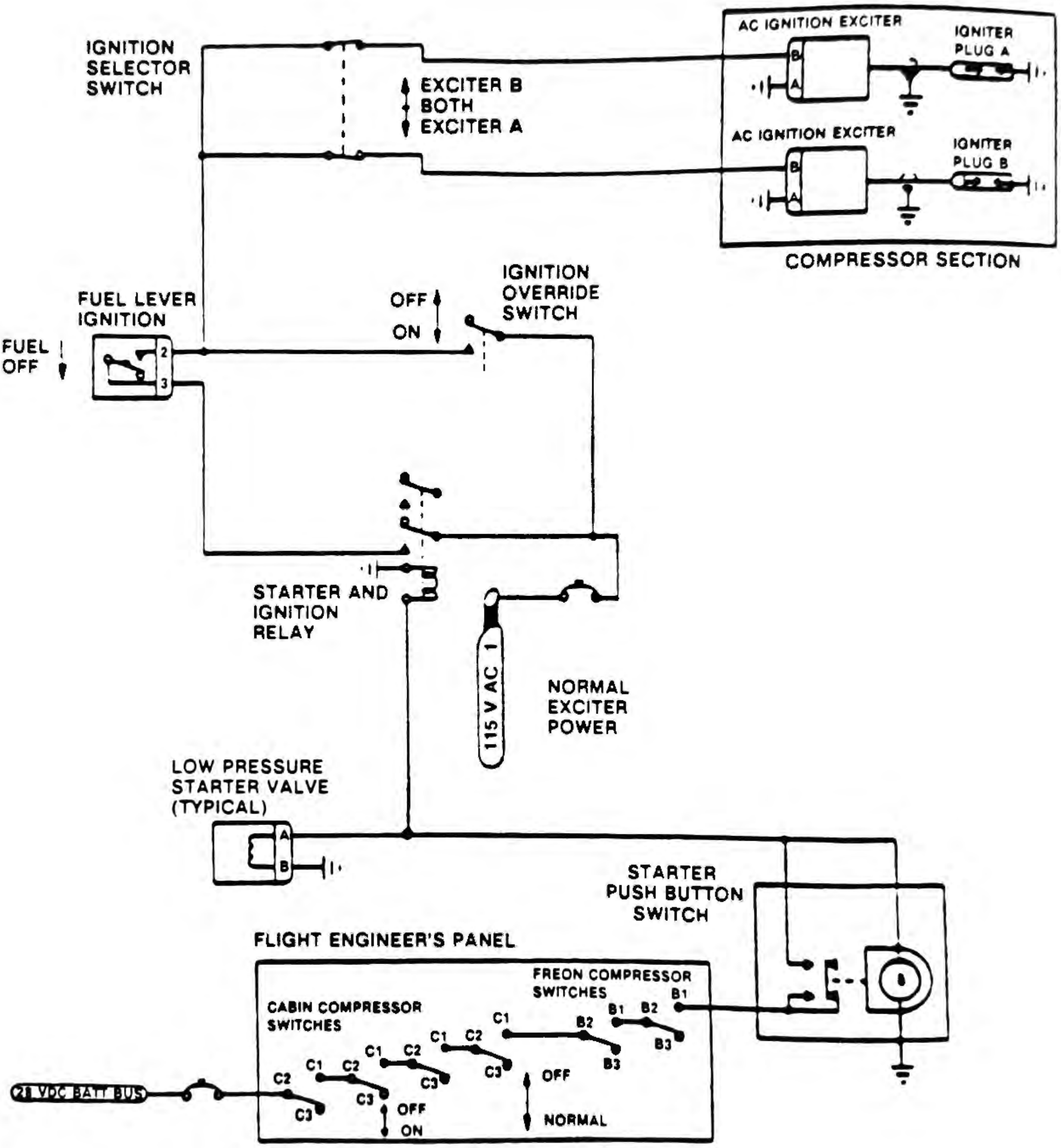
(1) The ignition selector switch normally is set in the BOTH position, which selects exciters A and B for simultaneous operation. Energizing the four AC buses arms the contacts of the start and ignition relays for the outboard engines and energizes the coils of the ignition power supply transfer relays for the inboard engines, which in turn arms the contacts of the start and ignition relays for these engines. Pressing the selected engine starter switch activates the coil of the start and ignition relay, which in turn closes the contacts to arm the fuel shutoff lever ignition switch for that engine. As the fuel shutoff lever is moved forward to the fuel on position, the contacts of the fuel shutoff lever ignition switch close, thus completing the circuit to the ignition exciters and to the igniter plugs.

(2) If the AC bus is not energized, an alternate method of energizing the exciters can be used for either engine 2 or 3. The ignition selector switch is placed in the BOTH position. The ignition power supply switch is placed in the armed position, completing the circuit from the battery bus through the contacts of the ignition power supply transfer relay to the ignition power supply control relay, energizing the coil. The contacts of the ignition power supply control relay close, completing the circuit to the ignition power supply from the DC battery bus. The AC output of the ignition power supply arms the contacts of the start and ignition relay and the contacts of the ignition override switch through the normally closed contacts of the ignition power supply transfer relay. Engine 2 or 3 now may be started either by pressing the respective starter switch or by actuating the associated ignition override switch.



STARTING -- ELECTRICAL SCHEMATIC
Figure 71-28

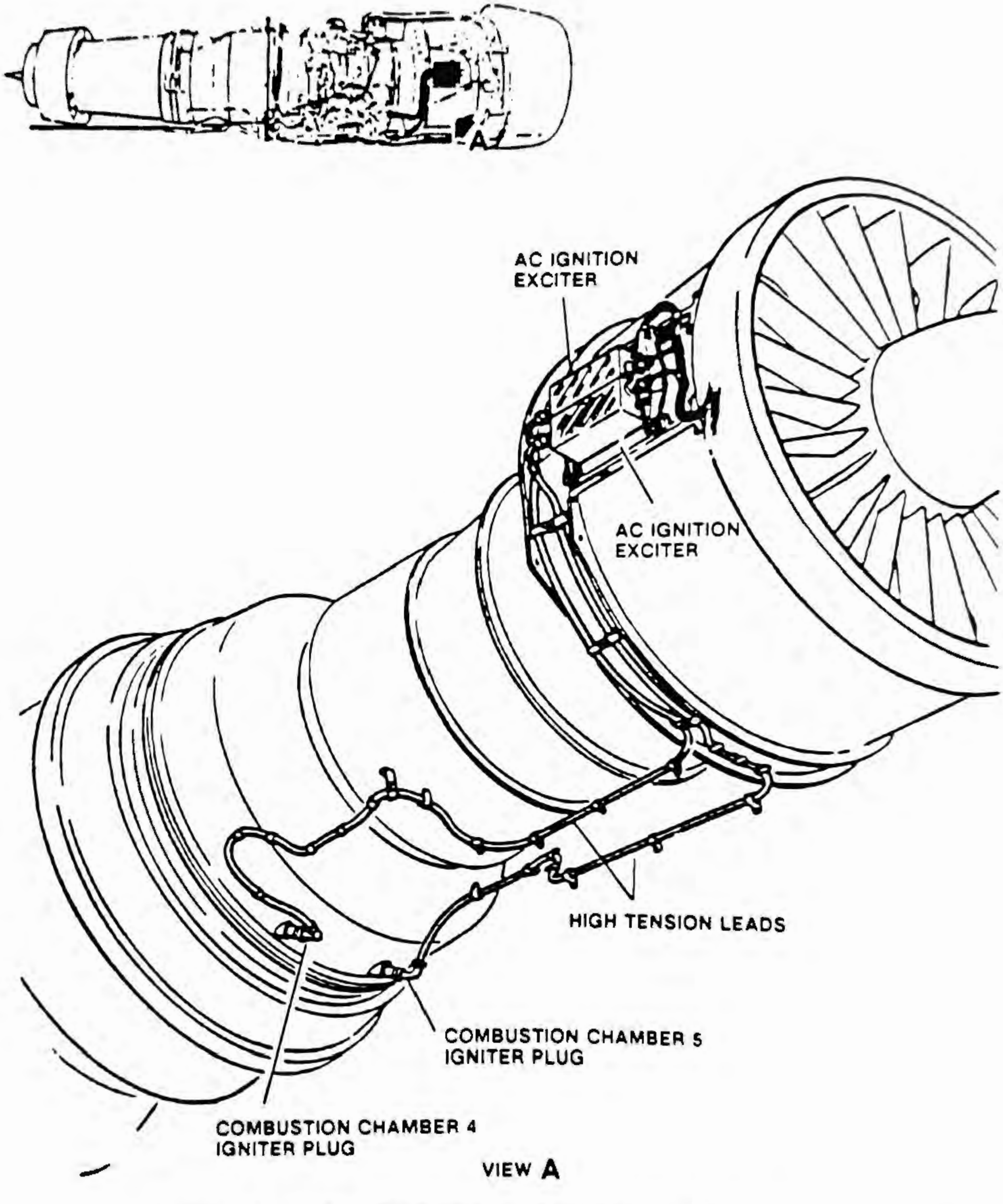
FTX80566



STARTING -- ELECTRICAL SCHEMATIC

FTX80567

Figure 71-29



A
AC IGNITION EXCITER
AC IGNITION EXCITER
HIGH TENSION LEADS
COMBUSTION CHAMBER 5 IGNITER PLUG
COMBUSTION CHAMBER 4 IGNITER PLUG
VIEW A

DISTRIBUTION SYSTEM -- GENERAL LOCATION FTX80568

Figure 71-30

B. Operation

The high tension leads carry the electrical energy from the ignition exciters to the igniter plugs. A gap between the electrode and the shell of the igniter plug is ionized by the surge of very high voltage, making it conductive. The storage capacitor in the exciter then discharges the remainder of its accumulated energy across the ionized plug gap. This results in a capacitive spark of very high energy which is capable of vaporizing globules of fuel and overcoming carbon deposits.

11. Switching - Description and Operation

A. General

(1) Control of the engine ignition system is provided by an ignition selector switch, start, and ignition switch, fuel shutoff lever ignition system, ignition power supply switch and an ignition override switch. These switches, located in the flight compartment, control the supply of power from the airplane electrical buses to the ignition exciters.

(2) The ignition selector switch is located on the overhead switch panel and provides ignition selection for the engines. The switch is a 3-position, selector switch with switch positions for A, BOTH, and B.

(3) The ignition override switch is located on the overhead switch panel and provides a means of bypassing the start and ignition relay and the fuel shutoff lever ignition switch. The switch is a 4-pole, double-throw, lever-lock toggle switch.

(4) A start and ignition switch, one for each engine, is located on the overhead switch panel in the flight compartment. This single-throw, on-off switch is included in the ignition circuit between the fuel shutoff lever ignition switch and the ignition selector switch.

(5) The fuel shutoff lever ignition switch is located inside the pilots' control pedestal. The switch is a single-pole, double-throw switch, connected in series with the start and ignition relay and the ignition selector switch.

(6) The ignition power supply switch is located on the flight engineer's instrument panel in the flight compartment. The switch provides a means of energizing the inboard engine exciters from the 28-volt DC

battery bus, through the ignition power supply, if the 115-volt AC bus is deenergized. This is a 3-position selector switch with positions for off, arm, and test.

B. Operation

(1) When the ignition selector switch is positioned to the desired ignition selection, a circuit is completed from the electrical buses to the ignition exciter.

(2) When the ignition override switch is placed in the on position, a circuit is completed from the 115-volt AC bus (outboard engines), or the ignition power supply transfer relay (inboard engines) to the ignition exciters.

(3) When the start and ignition switch is placed in the on position, a circuit is completed form the fuel shutoff lever ignition switch to the ignition selector switch.

(4) When the AC bus is energized, movement of the fuel shutoff lever 31/32 to 1-3/4 inches from the fuel off position completes the circuit to the respective ignition selector switch.

(5) When the ignition power supply switch is placed in the arm position, a circuit is completed from the 28-volt DC battery bus through the closed contacts of the ignition power supply control relay.

12. Engine Air - Description and Operation

A. Description

(1) The engine air system outlined in this chapter consists of engine anti-icing, accessory cooling, and compressor control systems. All systems are identical for each engine.

(2) The engine anti-icing system utilizes compressor bleed air to anti-ice the inlet guide vanes and inlet bullet, and low-pressure pneumatic air to anti-ice the nose cowl leading edge.

(3) Accessory cooling is provided by a jet pump system on the ground and by ram air during flight.

(4) The compressor control system provides operational flexibility by bleeding high-pressure compressor discharge air overboard during engine starting, acceleration, and operation at low thrust settings.

13. Accessory Cooling - Description and Operation

A. General (See Figure 71-31)

(1) Accessory cooling consists of the nacelle ventilating and generator cooling systems.

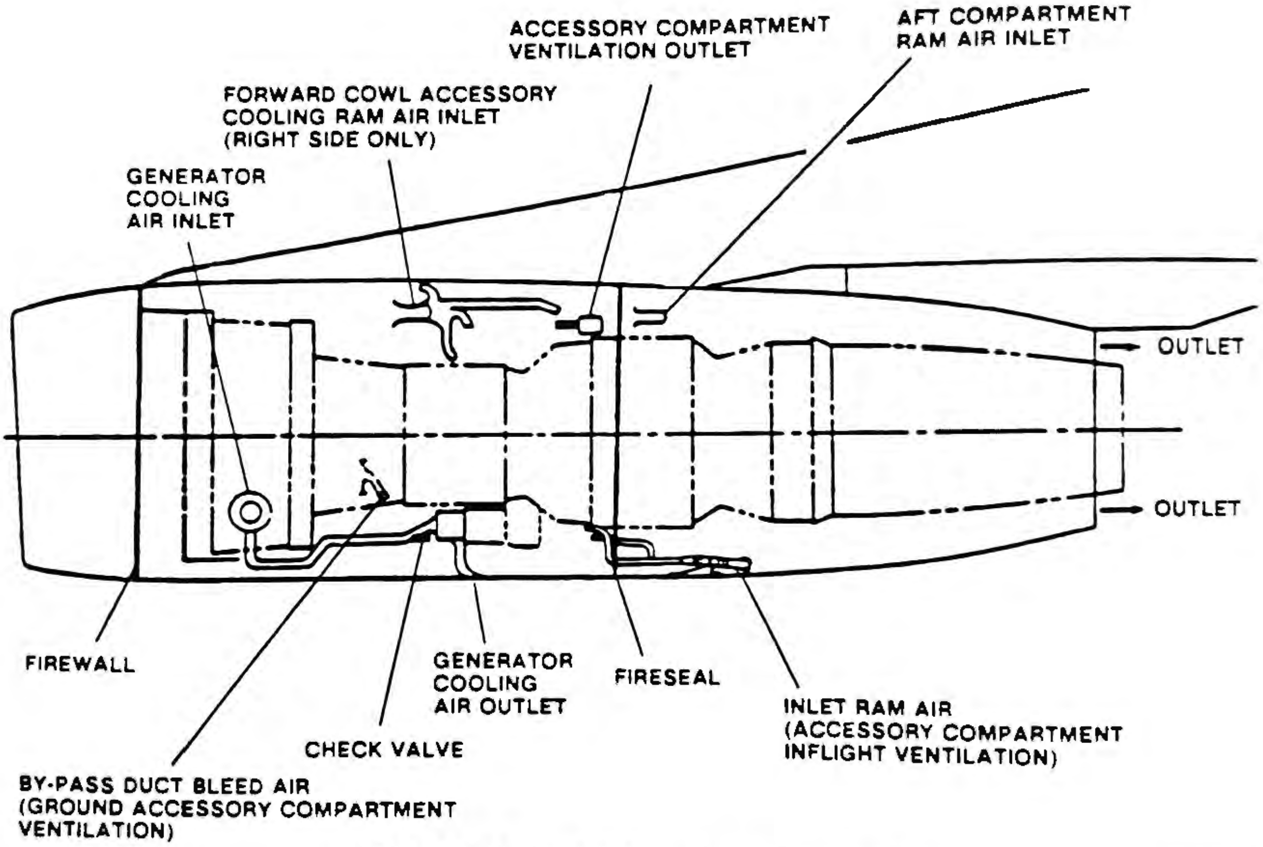
(2) The nacelle ventilating system prevents accumulation of combustible air mixtures in the nacelle and provides cooling air for the major portion of the engine-mounted accessory components.

(3) The nacelle ventilating system is divided into two separate subsystems:

(a) Accessory compartment ventilation

(b) Aft accessory compartment ventilation

(4) Inflight ventilation and cooling is provided by ram air. During ground operation, normal airflow provides sufficient ventilation and cooling for the aft accessory compartment. Accessory compartment ventilation is provided by bypass bleed air ported from a manifold attached to the fan bifurcated exhaust duct. The flow of air is regulated by an orifice installed in the duct. A fan, integral with the generator, circulates the cooling air for the generator during ground operations.


ACCESSORY COMPARTMENT VENTILATION OUTLET
AFT COMPARTMENT RAM AIR INLET
FORWARD COWL ACCESSORY COOLING RAM AIR INLET (RIGHT SIDE ONLY)
GENERATOR COOLING AIR INLET
OUTLET
OUTLET
FIREWALL
GENERATOR COOLING AIR OUTLET
FIRESEAL
INLET RAM AIR (ACCESSORY COMPARTMENT INFLIGHT VENTILATION)
CHECK VALVE
BY-PASS DUCT BLEED AIR (GROUND ACCESSORY COMPARTMENT VENTILATION)

ACCESSORY COOLING--SCHEMATIC

FTX80572

Figure 71-31

(5) The pneumatic portion of the engine ground cooling and blowaway jet system consists of the following components:

(a) Engine ground cooling and blowaway jet shutoff valve

(b) Accessory section ventilating manifolds

(c) CSD oil cooler jet pump

(d) Blowaway jet (vortex spoiler)

(6) The control portion of the engine ground cooling and blowaway jet system provides for manual and automatic opening and closing of the jet shutoff valve. The control portion of the system consists of the following components:

(a) Ground cooling and blowaway jet shutoff switch

(b) Engine ground cooling and blowaway jet shutoff valve

(c) Engine ground control relay

(d) Takeoff warning and jet pump arming relays

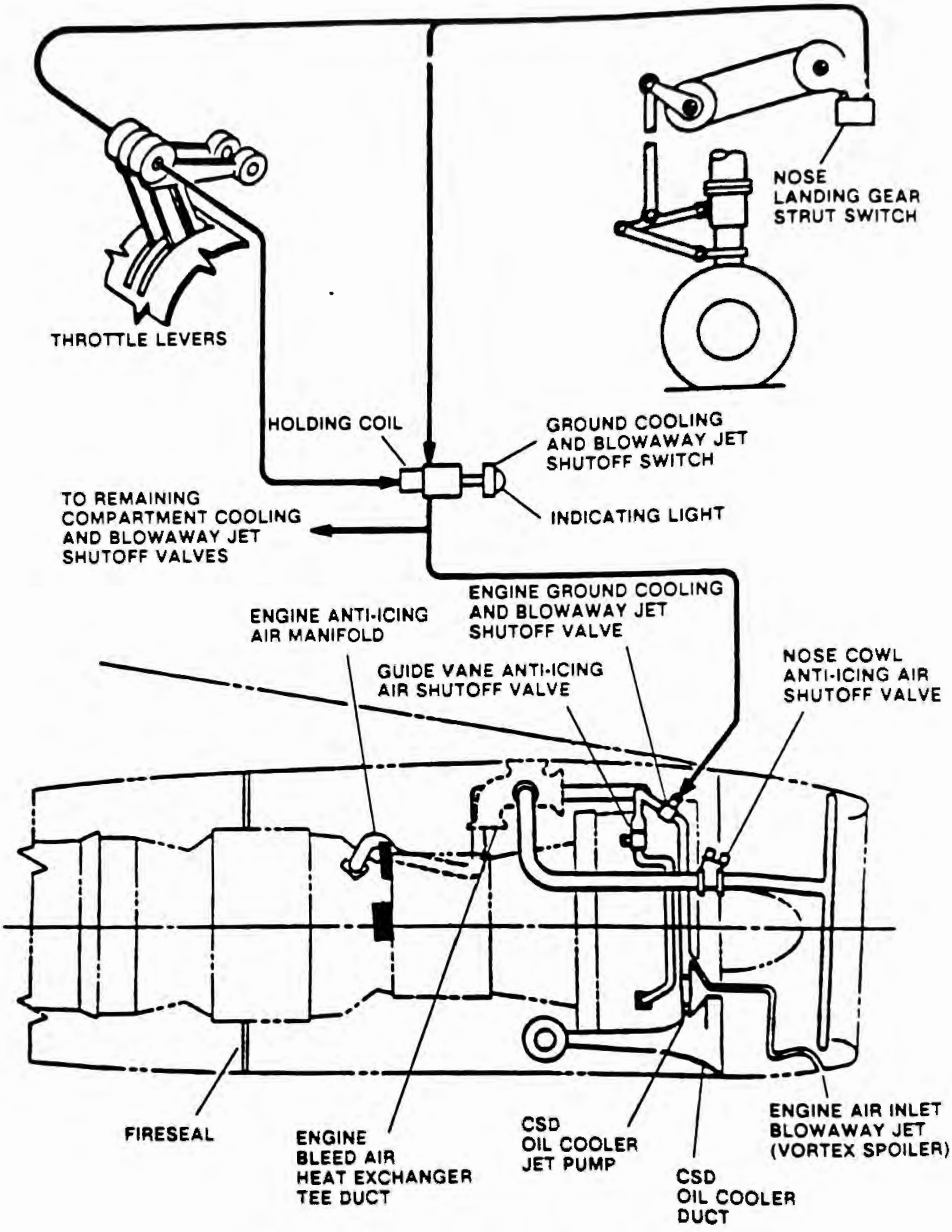
(e) Throttle lever limit switches

B. System Components (See Figure 71-32)

(1) Engine Ground Cooling and Blowaway Jet Shutoff Valve

(a) The engine ground cooling and blowaway jet shutoff valve controls pneumatic pressure to the CSD oil cooler, jet pump, and blowaway jet (vortex spoiler). The valve is electrically controlled and pneumatically actuated and is located on the upper right side of the engine.

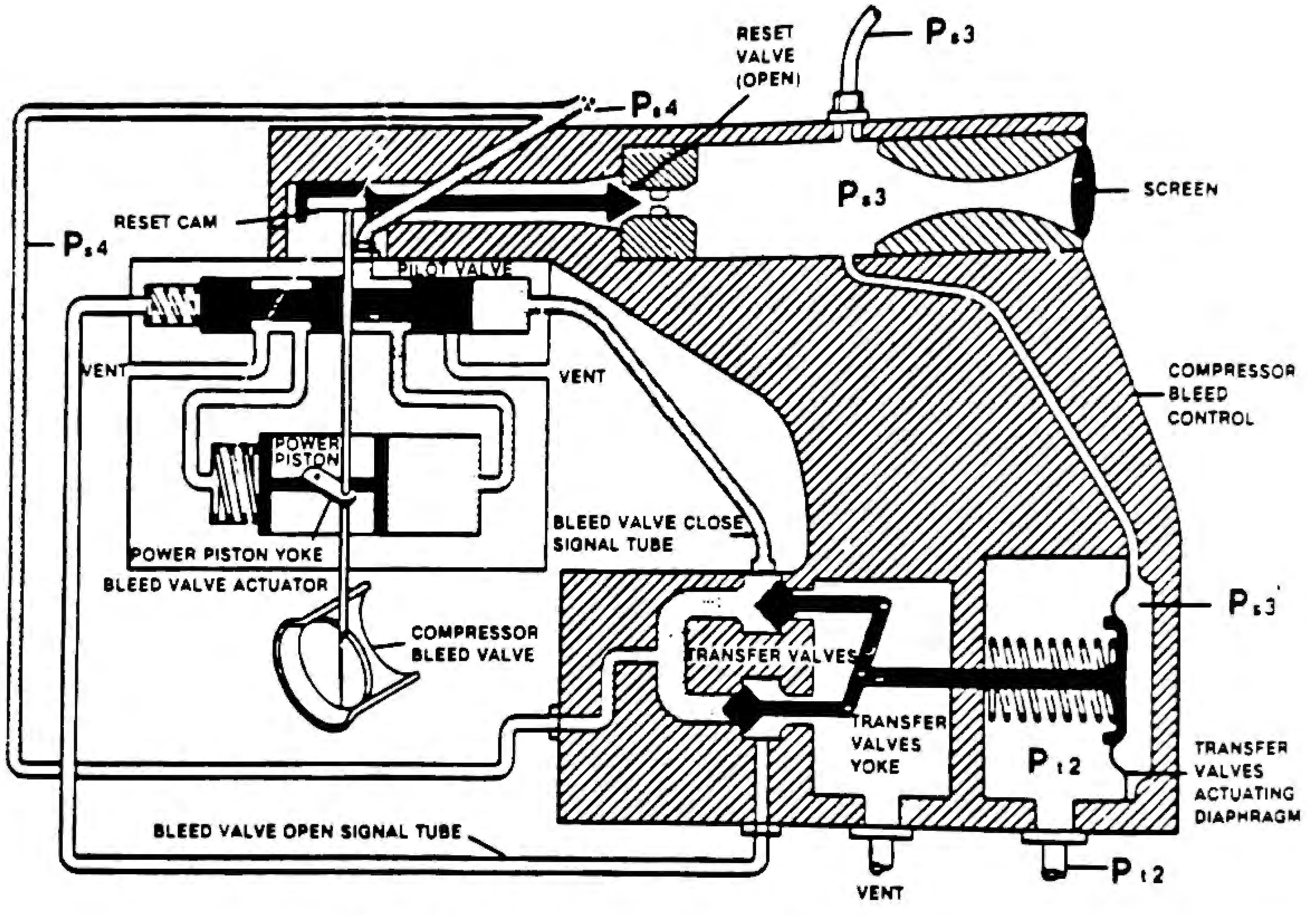
(b) The valve is automatically energized to the open position when the nose gear strut is compressed and closes when the strut extends. The valve can be closed manually during ground operation by utilizing the ground cooling and blowaway jet shutoff switch.


THROTTLE LEVERS
NOSE LANDING GEAR STRUT SWITCH
HOLDING COIL
GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
TO REMAINING COMPARTMENT COOLING AND BLOWAWAY JET SHUTOFF VALVES
INDICATING LIGHT
ENGINE ANTI-ICING AIR MANIFOLD
ENGINE GROUND COOLING AND BLOWAWAY JET SHUTOFF VALVE
GUIDE VANE ANTI-ICING AIR SHUTOFF VALVE
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE
FIRESEAL
ENGINE BLEED AIR HEAT EXCHANGER TEE DUCT
CSD OIL COOLER JET PUMP
CSD OIL COOLER DUCT
ENGINE AIR INLET BLOWAWAY JET (VORTEX SPOILER)

ACCESSORY COOLING--SCHEMATIC

FTX80573

Figure 71-32



COMPRESSOR CONTROL SCHEMATIC

FTX80575

Figure 71-35

(2) Engine Ground Cooling and Blowaway Jet Shutoff Switch

(a) The engine ground cooling and blowaway jet shutoff switch provides common control for the jet pump shutoff valve on all engines. The switch, located on the flight engineers switch panel, is used to manually control the operation of the jet pump shutoff valve. The switch incorporates a blue translucent knob with an integral indicating light.

(b) A ground control relay connects power to the shutoff switch when the nose gear strut is compressed and disconnects power when the strut extends. When the knob is depressed, the holding coil of the switch is energized by the takeoff warning and jet pump arming relays, which, in turn, are operated by the throttle lever limit switches.

(c) When the shutoff switch is in the on (out) position, the light is on and the jet pump shutoff valve is open. The switch is spring-loaded to the on position. When the switch is depressed, it is held in by the holding coil provided that throttle levers 1 and 2, 3 and 4, any combination of three or four throttle levers are advanced to actuate the throttle lever switches. When the switch is depressed (off position), the valves close and the light goes off.

C. Operation

(1) During flight, the generator is cooled by ram air admitted through the generator cooling air inlet duct connected to the generator. Air passes through the generator and exhausts overboard through an outlet in the bottom of the cowl doors. During ground operation, a fan, integral with the generator, circulates the required cooling air.

(2) During flight, cooling air for the forward accessory compartment enters through inlets in the right cowl door and aft cowl. Air entering through the right cowl door inlet is directed, through manifolds, to flow around the hydraulic hoses, and pressure regulator, interstage bleed, and modulating control valves. The air then exhausts through the outlets in the cowl doors. Air entering the inlets in the aft cowl is directed forward, through manifolds, to flow around the left and right igniter units, hydraulic pump, tachometer generator, and compressor section of the engine. The air then exhausts through the outlets in the cowl doors. Cooling air for the aft compartment enters through inlets

in the aft cowl. The air flows around the combustion and turbine section of the engine and exhausts overboard through the exhaust nozzle of the engine.

(3) Operation of the ground cooling and blowaway jet system (see Figure 71-33) is initiated when the nose gear strut is compressed. The jet pump shutoff valve opens automatically and the ground cooling and blowaway jet shutoff switch indicating light comes on. Air flows from the blowaway jet shutoff valve to the CSD oil cooler jet pump and blowaway jet (vortex spoiler). The CSD oil cooler jet pump discharges high velocity air into the CSD oil cooler outlet duct to create a flow of cooling air (by aspiration) through the oil cooler during ground operations. The blowaway jet directs a stream of high velocity air toward the ground below the nose cowl inlet. This air blast, prevents the formation of a vortex (whirlwind) between the nose cowl inlet and ground to prevent dirt and debris from entering the engine inlet.

(4) During ground operations, the ground cooling and blowaway jet can be closed manually by depressing the ground cooling and blowaway jet shutoff switch. When the switch is depressed, power is removed from the shutoff valve solenoids; the valves close, and switch indicating light goes off. If throttles 1 and 2, 3 and 4, any combination of three or four throttles are advanced to actuate the throttle lever switches when the switch is depressed, the switch holding coil is energized and will hold the switch in the depressed (off) position.

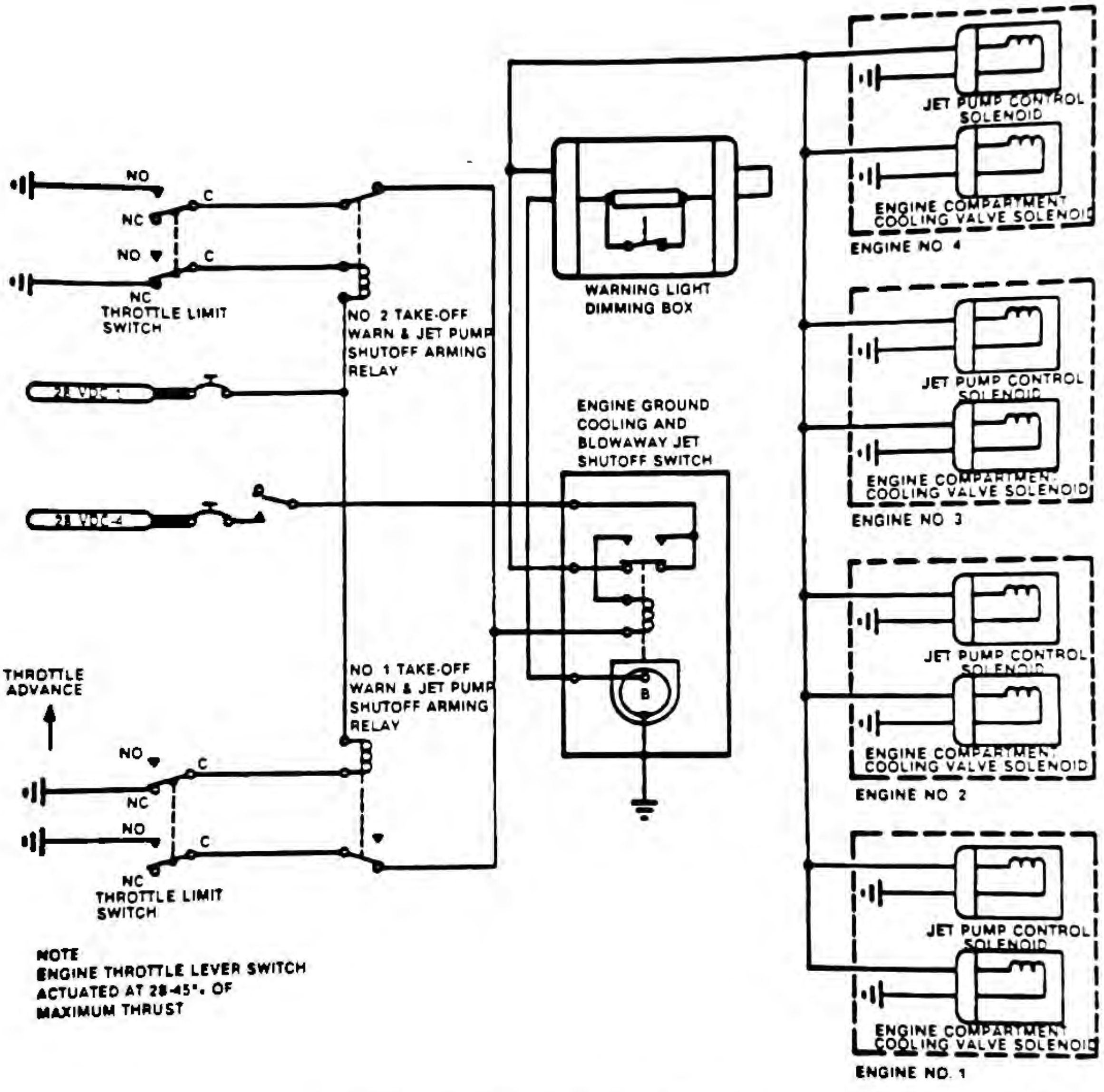
14. Compressor Control - Description and Operation

A. General (See Figure 71-34)

(1) The compressor control system provides operational flexibility by bleeding low-pressure compressor discharge air overboard during engine starting and operation at low thrust settings. The compressor control system consists of a compressor bleed valve and control, connecting tubing, and a bleed valve duct.

(2) The actuator control functions under the influence of differential air pressure scheduling either open or closed bleed valve operation.

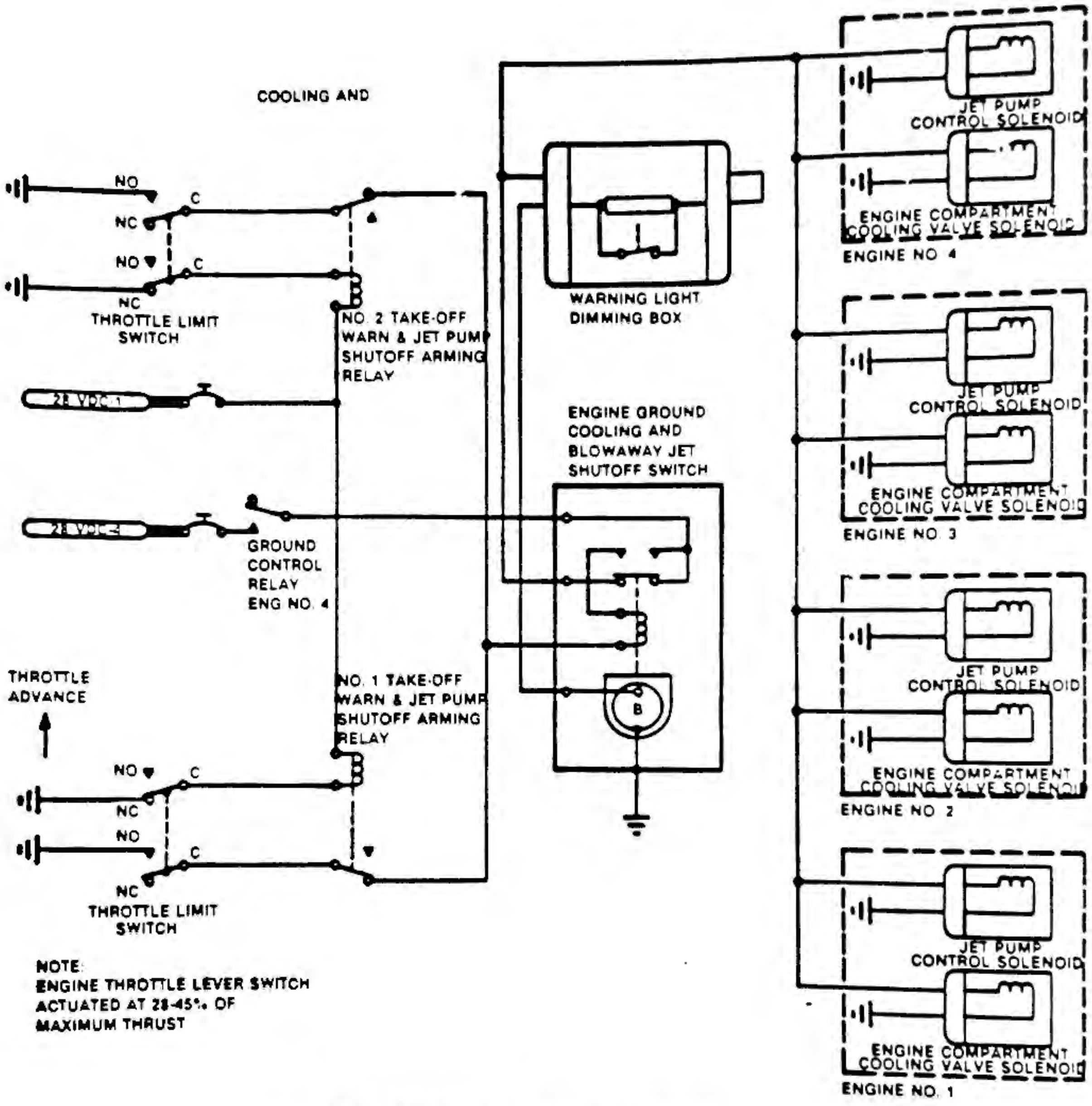
(3) The compressor bleed valve and control, connection tubing, and bleed valve duct are located on the upper left side of each engine.


NO
NC
C
NO
C
NC
THROTTLE LIMIT SWITCH
NO 2 TAKE-OFF WARN & JET PUMP SHUTOFF ARMING RELAY
28 VDC-1
28 VDC-4
WARNING LIGHT DIMMING BOX
ENGINE GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
B
THROTTLE ADVANCE
NO 1 TAKE-OFF WARN & JET PUMP SHUTOFF ARMING RELAY
NO
C
NC
NO
C
NC
THROTTLE LIMIT SWITCH
NOTE
ENGINE THROTTLE LEVER SWITCH ACTUATED AT 28-45°, OF MAXIMUM THRUST
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO 4
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO 3
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO 2
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO. 1

INDICATING -- SCHEMATIC

FTX80577

Figure 71-36

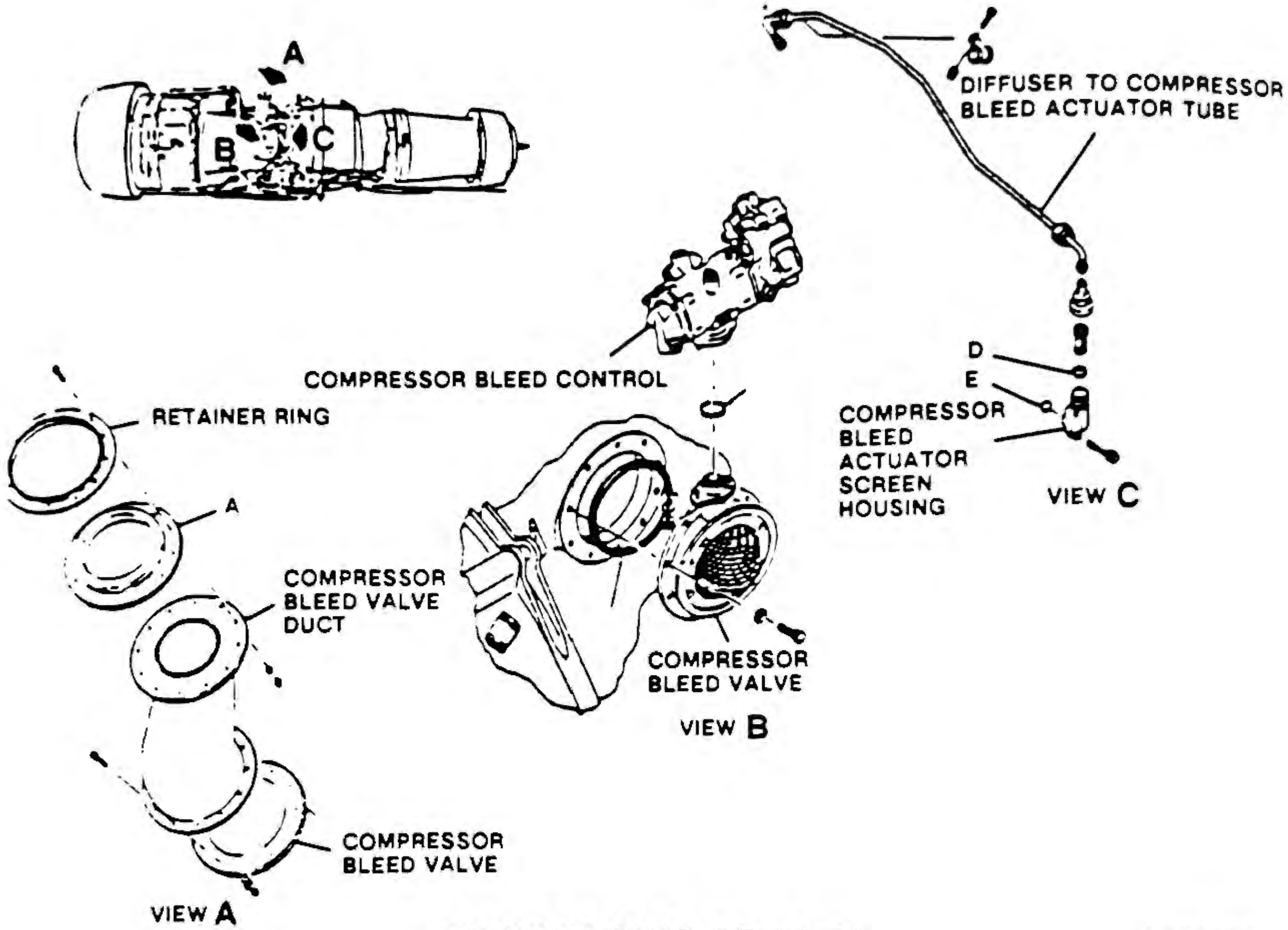

COOLING AND
NO
C
NC
NO
C
NC
THROTTLE LIMIT SWITCH
NO. 2 TAKE-OFF WARN & JET PUMP SHUTOFF ARMING RELAY
28 VDC-1
28 VDC-2
GROUND CONTROL RELAY ENG NO. 4
WARNING LIGHT DIMMING BOX
ENGINE GROUND COOLING AND BLOWAWAY JET SHUTOFF SWITCH
B
THROTTLE ADVANCE
NO. 1 TAKE-OFF WARN & JET PUMP SHUTOFF ARMING RELAY
NO
C
NC
NO
C
NC
THROTTLE LIMIT SWITCH
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO. 4
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO. 3
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO. 2
JET PUMP CONTROL SOLENOID
ENGINE COMPARTMENT COOLING VALVE SOLENOID
ENGINE NO. 1

NOTE:
ENGINE THROTTLE LEVER SWITCH ACTUATED AT 28-45% OF MAXIMUM THRUST

GENERAL -- SCHEMATIC

FTX80570

Figure 71-33


A
B
C
DIFFUSER TO COMPRESSOR BLEED ACTUATOR TUBE
COMPRESSOR BLEED CONTROL
D
E
COMPRESSOR BLEED ACTUATOR SCREEN HOUSING
VIEW C
RETAINER RING
A
COMPRESSOR BLEED VALVE DUCT
COMPRESSOR BLEED VALVE
VIEW B
COMPRESSOR BLEED VALVE
VIEW A

COMPRESSOR CONTROL

FTX80574

Figure 71-34

B. Operation (See Figure 71-35)

(1) When cranking first begins, air flows inward through the compressor bleed valve to the inlet of the high-pressure compressor, relieving part of the windmilling load of the low-pressure compressor. By the time the engine starts, the second, third, and fourth stage turbines will be driving the low-pressure compressor, and air will be coming out the compressor bleed valve. The bleed valve remains open after starting, providing good acceleration characteristics for the engine.

(2) As the power lever is advanced, added energy from the increased fuel burned is used to accelerate the high-pressure compressor. The high-pressure compressor, which is lighter and smaller in diameter than the low-pressure compressor, has a lower inertia than the low-pressure compressor. As the high-pressure compressor picks up speed, airflow through the combustion chambers increases. The exhaust from the first stage of the turbine will gradually increase the speed of the remaining stages. The low-pressure compressor slowly increases in speed. At approximately 62 percent of low-pressure compressor speed, the bleed valve closes, and remains closed until speed is reduced.

(3) The compressor bleed valve control schedules bleed valve operation to a varying front compressor pressure ratio: the total pressure at the front compressor inlet (P_t2) to the pressure at the front compressor discharge (P_s3). This ratio varies as a function of the engine thrust setting, aircraft speed, air temperature, and altitude.

(4) The front compressor discharge pressure (P_s3) is used to achieve a high static Pressure (P_s3) on one side of the transfer valve diaphragm. This is done by means of a dual orifice system within the control. The low pressure (P_t2) is induced to the other side of the diaphragm. With the help of spring force to P_t2, a balance is obtained between P_t2 and P_s3. Any deviation from the null position produces a corrective action by varying the low-pressure bleed valve.

(5) The displacement change resulting from a change in pressure ratio (P_t2/P_s3) is mechanically transmitted through a yoke assembly to a transfer valve assembly. The transfer valve assembly consists of a two poppet-type transfer valve. This valve transmits the desired signal pressure to the bleed valve actuator assembly to schedule either open or closed bleed valve positions. Engine high-pressure compressor discharge air (P_s4) is always supplied to one end of each poppet valve; and ambient pressure, to the other end. Therefore, depending on the direction of the control signal, the transfer valves will be scheduled either in the bleed open or bleed closed position and the high-pressure compressor discharge air will be directed through the transfer valve to either the open or closed signal line to the bleed valve and actuator.

(6) A reset feature designed into the control accommodates the step change in high compressor engine pressure between bleed closed and bleed open. The reset is necessary as an appreciable change in engine low-pressure compressor discharge occurs between the bleed open and bleed closed positions. If this change is not compensated for, excessive hysteresis in the control will occur. The reset mechanism is a mechanical feedback system from the bleed valve. If the bleed valve is in the closed position, the reset valve will be open, and if the bleed valve is in the open position, the reset valve will be in the closed position.

15. Indicating - Description and Operation

A. General

A ground cooling and blowaway jet pump indicating system is provided. The system provides visual indication of jet shutoff valve operation and consists of a shutoff switch, valves, relays, and a switch for each throttle lever. The ground cooling and blowaway jet shutoff switch, located in the flight compartment, has a blue translucent pushbutton knob, with an integral indicating light. The jet shutoff valve is located on the upper right side of each engine. The four throttle lever actuated switches, located in the control pedestal, operate the takeoff warning and jet pump shutoff arming relays.

B. Operation

(1) Ground Cooling and Blowaway Jet Pump Indicating System (See Figure 71-36)

(a) The integral light in the engine ground cooling and blowaway jet shutoff switch comes on when the jet shutoff valves open. A ground control relay supplies power to the shutoff switch when the airplane is on the ground and disconnects power when the nose gear strut is extended. Depressing the shutoff switch (spring loaded in the out position) disconnects power from the shutoff valve. The valve closes, and the indicating light goes off. Releasing the shutoff switch knob allows the knob to return to the out (open) position, completing a circuit to the shutoff valves. The valves open, and the indicating light comes on. If throttle levers No. 1 and 2, No. 3 and 4, or any combination of three or four throttles are advanced to actuate the throttle lever switches when the shutoff switch is depressed, the holding coil of the switch is energized by the takeoff warning and jet pump arming relays and stays in the depressed position.

(b) During takeoff, the nose gear switch is actuated to the closed position when the nose gear strut is extended and the circuit to the shutoff valves and switch is broken. If the shutoff switch is in the on position (knob out, light on), the valves will close, and the indicating light will go off. If the shutoff switch is in the off position (knob in, light off), the switch returns to the on position (knob out), and the indicating light remains off.

(c) During landing, the nose gear switch is actuated to the open position completing a circuit to the shutoff valves and switch. The valves open, and the indicating light comes on.

16. Engine Controls - Description and Operation

A. Description

(1) Engine controls consist of throttle and thrust reverser levers, fuel shutoff levers, and four fire control handles mounted aft of the overhead switch panel.

(1) Throttle and thrust reverser, and fuel shutoff controls, are mechanically linked to the engine controls by cables. The throttle control cables extend from drums in the control pedestal to a power control drum in each pylon. The fuel shutoff control cables extend from sectors in the control pedestal to a fuel shutoff drum mounted beside each power control drum. The power control drum and fuel shutoff drum are connected to the engine stub shaft by pushrods. The engine stub shaft is connected to the fuel control by pushrods.

(2) Fire control handles, located aft of the overhead switch panel, provide a means of engine emergency shutdown. The handles are connected by cables to fuel fire shutoff valves and pneumatic fire shutoff valves for all engines, and to hydraulic fire shutoff valves for inboard engines.

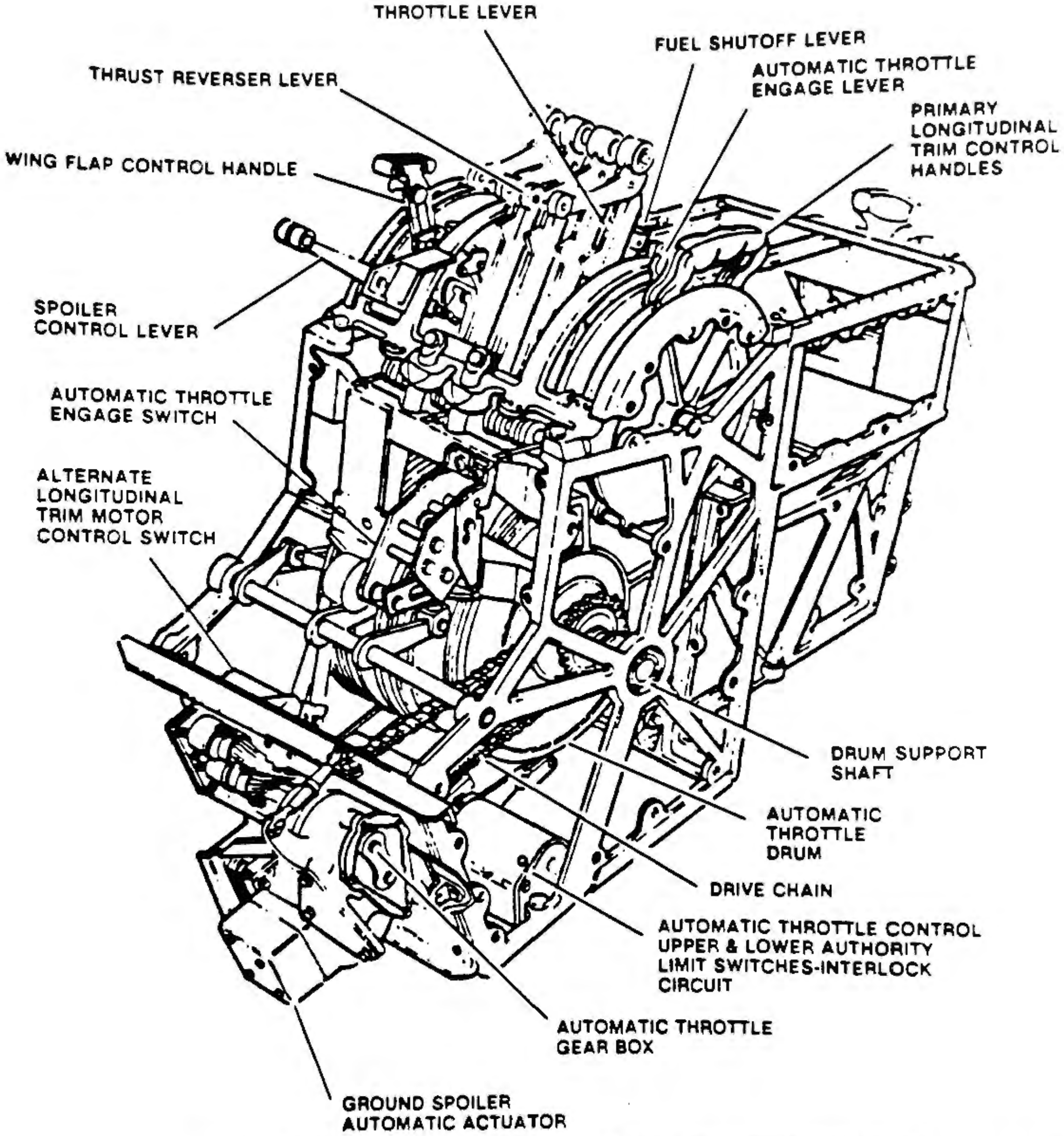
17. Power Control - Description and Operation

A. General (See Figure 71-37)

(1) Power control consists of throttle and fuel shutoff systems which provide the means of controlling engine fuel and power.

(2) The throttle system provides a means of setting the forward thrust of the engine from idle to takeoff thrust, and a means of actuating and controlling the thrust reverser system. The system consists of throttle and thrust reverser levers mounted on a lever support shaft in the control pedestal. Each lever is connected by pushrod to a throttle control drum, which in turn is connected by cables to a power control drum in the engine pylon. The power control drum is connected by pushrods to a crank on the engine stub shaft. The engine stub shaft crank is connected by pushrod to the fuel control on the engine.

(3) The fuel shutoff system provides on/off control of the fuel at the inlet to the engine fuel control. The system consists of fuel shutoff levers mounted on the lever support shaft in the control pedestal. Each lever is connected by cables to a fuel shutoff drum mounted beside the power control drum in the engine pylon. The fuel shutoff drum is connected by pushrods to a crank on the engine stub shaft. The engine stub shaft crank is connected by pushrod to the fuel control on the engine.


THROTTLE LEVER
FUEL SHUTOFF LEVER
THRUST REVERSER LEVER
AUTOMATIC THROTTLE ENGAGE LEVER
PRIMARY LONGITUDINAL TRIM CONTROL HANDLES
WING FLAP CONTROL HANDLE
SPOILER CONTROL LEVER
AUTOMATIC THROTTLE ENGAGE SWITCH
ALTERNATE LONGITUDINAL TRIM MOTOR CONTROL SWITCH
DRUM SUPPORT SHAFT
AUTOMATIC THROTTLE DRUM
DRIVE CHAIN
AUTOMATIC THROTTLE CONTROL UPPER & LOWER AUTHORITY LIMIT SWITCHES-INTERLOCK CIRCUIT
AUTOMATIC THROTTLE GEAR BOX
GROUND SPOILER AUTOMATIC ACTUATOR

CONTROL PEDESTAL -- GENERAL ARRANGEMENT FTX80578

Figure 71-37

18. Throttle Systems - Description and Operation

A. General

(1) Four throttles, one for each engine, are installed on the control pedestal. They provide a means of setting the forward thrust of the engines from idle to takeoff thrust. Each throttle has a forward travel of 60 degrees and is linked by a pushrod to a throttle control drum in the control pedestal. The throttle control drum is connected by a cable system to a power control drum in the pylon of the corresponding engine.

(2) Four thrust reverser levers, one for each engine, are hinged at the top of the throttles. The thrust reverser levers are connected to the same drums and cable systems used by the throttles, but cannot be operated until the throttles are in the idle position.

(3) An automatic throttle system has been deactivated.

(4) Movement of the throttles from idle toward the full forward position produces engine thrust as desired. As the throttle is moved through the 60-degree forward thrust range, the motion is transmitted from the throttle handle crank, through a pushrod, to the throttle control drum. This force rotates the throttle control drum, which transmits the motion by a cable system to the power control drum. Power control drum movement is transmitted by a pushrod to the fuel control on the engine.

(5) A sequencing cam is attached to each throttle control drum in the control pedestal. As the throttle control drum rotates forward, the sequencing cam contacts three switches located in the lower rear portion of the control pedestal. The lower switch is the landing gear warning switch. The center switch is the low-pressure pneumatic valve selector, ground cooling and blowaway jet shutoff switch, and takeoff warning switch. The upper switch is the freon control switch.

(6) Each thrust reverser lever has a total travel of 117 degrees. Movement of the lever through approximately the first half of travel actuates the thrust reverser mechanism in the exhaust section of the engine and a feel detent in the fuel control is engaged. Full movement of the lever above the feel detent produces maximum reverse thrust for ground roll or ground operation. Each throttle system is provided

with a thrust reverser gate interlock mounted under the cabin floor forward of the control pedestal. The gate is a mechanical interlock designed to limit reverse thrust of the engines depending on the position of the landing gear handle. When the landing gear handle is in the up position, the outboard reverser levers are limited to forward idle and the inboard reverser levers are limited to the reverse thrust detent position. With the landing gear handle in the down position, the outboard reverser levers are limited to the reverse thrust detent position and the inboard reverser levers will have full reverse power command.

(7) Movement of the throttle to the idle position allows actuation of the thrust reverser lever. As the lever moves through the 117-degree range, the thrust reverser attaching link moves to apply an upward force to the throttle handle crank assembly in the control pedestal. As the forward end of the throttle handle crank moves upward, the motion is transmitted by a pushrod to the throttle control drum. This force rotates the throttle control drum which transmits the motion through the normal throttle system to the power control drum at the engine.

(8) A gust lock control lever, located on the right side of the control pedestal, is interlocked with the throttle levers to prevent application of take-off power to the inboard engines when the gust lock lever is in the locked position. With the gust lock lever in the locked position, the inboard throttles can be advanced approximately 15/16 inch from the idle position before the interlock stop is contacted. The outboard throttles can be advanced to full takeoff power when the gust lock lever is at the locked position.

19. Fuel Shutoff Systems - Description and Operation

A. General

(1) Four fuel shutoff levers, one for each engine, are installed on the control pedestal aft of the throttle and thrust reverser levers. The fuel shutoff levers actuate the respective fuel shutoff valve to admit fuel to the engine fuel control during starting and operation, and to shut off fuel for engine shutdown.

B. Operation

(1) The pressure ratio system receives engine inlet air pressure form the P_t2 probe, and exhaust pressure from the P_t7 probes. The transmitter measures these pressures and computes a ratio between them. An electrical signal corresponding to the resultant pressure ratio is conducted to the pressure ratio transmitter, which converts the signal to a dial indication representative of the ratio.

(2) The N_1 tachometer generator is driven by accessory drive gearing from the low-pressure compressor. Similarly, the N_2 tachometer generator is driven by gearing from the high-pressure compressor. Generator rotation develops a 3-phase electrical signal whose frequency is a function of generator speed. The electrical signal is converted by the indicator to display percent of permissible compressor rpm.

23. Pressure Ratio System - Description and Operation

A. General (See Figure 71-40)

(1) Engine pressure ratio is used as the operating variable for measuring the thrust output of dual-compressor turbojet engines. Incoming air pressure is measured at the engine inlet, and exhaust pressure is measured at the turbine exhaust. A ratio between the two pressures is established and then displayed on an indicator in the flight compartment.

(2) The pressure ratio system for each engine consists of a pressure ratio transmitter, an indicator, an inlet pressure-sensing probe (P_t2), and six turbine exhaust pressure-sensing probes (P_t7). The system is supplied with 115-VAC through a circuit breaker, located on the main circuit breaker panel.

(3) The pressure ratio transmitter is mounted above the engine in the pylon. A door in the leading edge of the pylon provides access. The transmitter consists of two aneroid bellows, a force balance-sensing unit, a followup motor and gear train, and a transmitter synchro. These components are contained in a pressure-sealed housing which is provided with external pressure connections and an electrical connection.

(2) The fuel shutoff levers are attached to sectors mounted on a lever support shaft in the control pedestal. Each lever sector is connected by cables to a fuel shutoff drum mounted in the engine pylon. The fuel shutoff drum is connected by pushrods to the fuel control on the engine.

(3) A cam is attached to each fuel shutoff lever sector in the control pedestal. As the fuel shutoff levers are moved from fuel off to fuel on position, the cam actuates an ignition switch to energize the ignition system.

20. Emergency Shutdown - Description and Operation

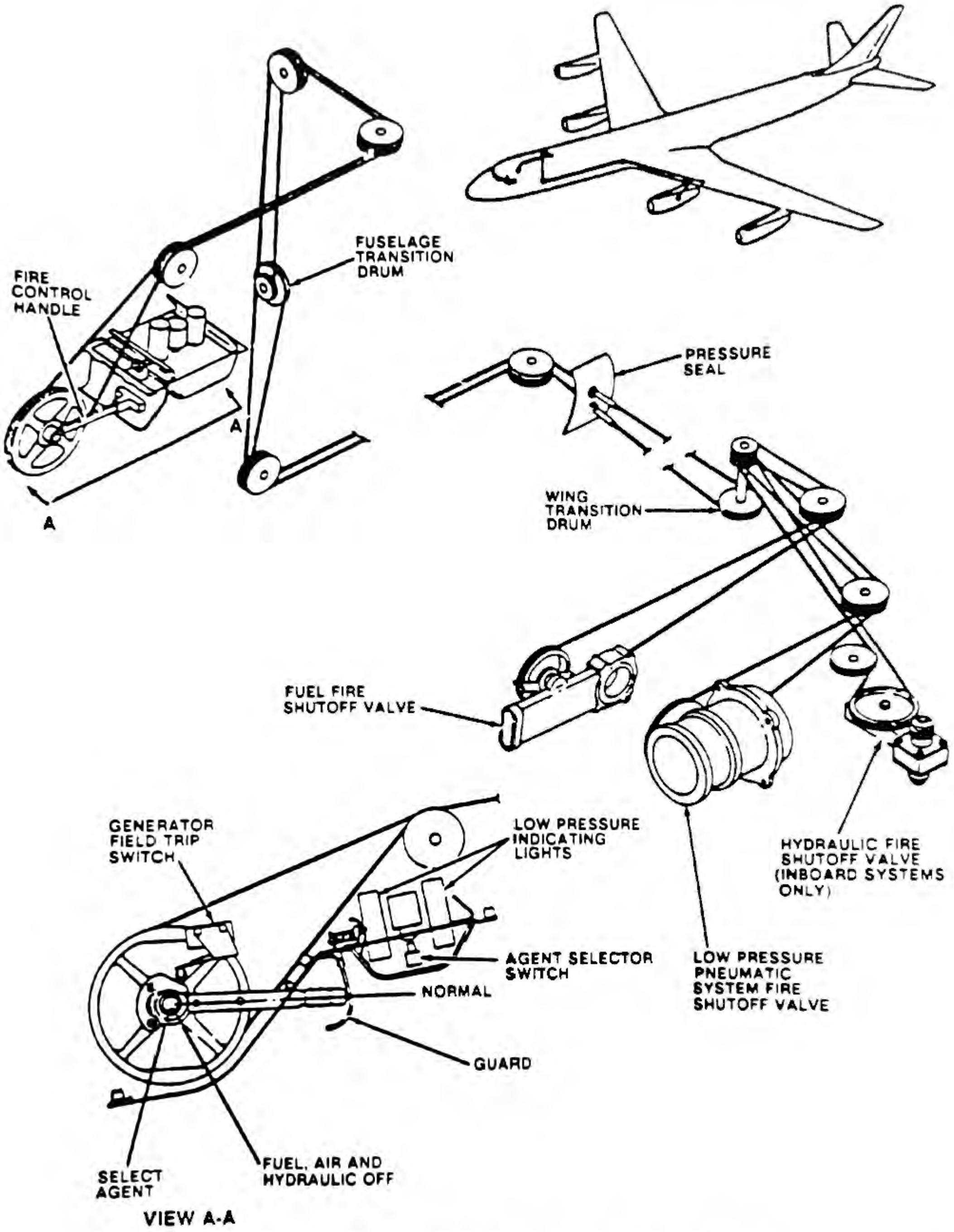
A. General (See Figure 71-38)

(1) Each engine is equipped with an independent fire control handle mounted aft of the overhead switch panel. Lights are provided within the handle to indicate detection of an engine fire.

(2) The fire control handles are connected by cables, linked through transition drums, to shutoff valves in the wings and pylons. The fire control handles have three positions: normal; fuel, air and hydraulic off; and select agent.

(3) A cam is attached to the cable drum of each fire control handle to actuate a generator field trip and pneumatic system shutoff switch when the handle is away from the normal position.

(4) A ball fitting is provided on each handle operating cable to release a door over the fire extinguisher agent discharge switches whenever the control handle is in the select agent position.


FIRE CONTROL HANDLE
FUSELAGE TRANSITION DRUM
A
A
PRESSURE SEAL
WING TRANSITION DRUM
FUEL FIRE SHUTOFF VALVE
GENERATOR FIELD TRIP SWITCH
LOW PRESSURE INDICATING LIGHTS
HYDRAULIC FIRE SHUTOFF VALVE (INBOARD SYSTEMS ONLY)
AGENT SELECTOR SWITCH
LOW PRESSURE PNEUMATIC SYSTEM FIRE SHUTOFF VALVE
NORMAL
GUARD
SELECT AGENT
FUEL, AIR AND HYDRAULIC OFF
VIEW A-A

EMERGENCY SHUTDOWN SYSTEM SCHEMATIC

FTX80579

Figure 71-38

B. Operation

(1) The emergency shutdown system is controlled by the fire control handles located aft of the overhead switch panel. Movement of a fire control handle toward the fuel, air and hydraulic off position actuates a switch which opens the generator field circuit to deactivate the generator and, also, actuates and closes the engine pneumatic pressure regulating valve. When the handle reaches the fuel, air and hydraulic off position, the fuel fire shutoff valve, pneumatic fire shutoff valve, and hydraulic fire shutoff valve (inboard systems only) are closed. These valves remain closed and the switch remains actuated throughout the remainder of the fire control handle range of movement in a forward direction.

(2) Continued movement of the fire control handle to the select agent position releases the access door to the fire extinguisher agent discharge control switch for the left or right engine systems.

(3) Operation of an agent discharge control switch discharges a fire extinguishing agent container to the selected engine.

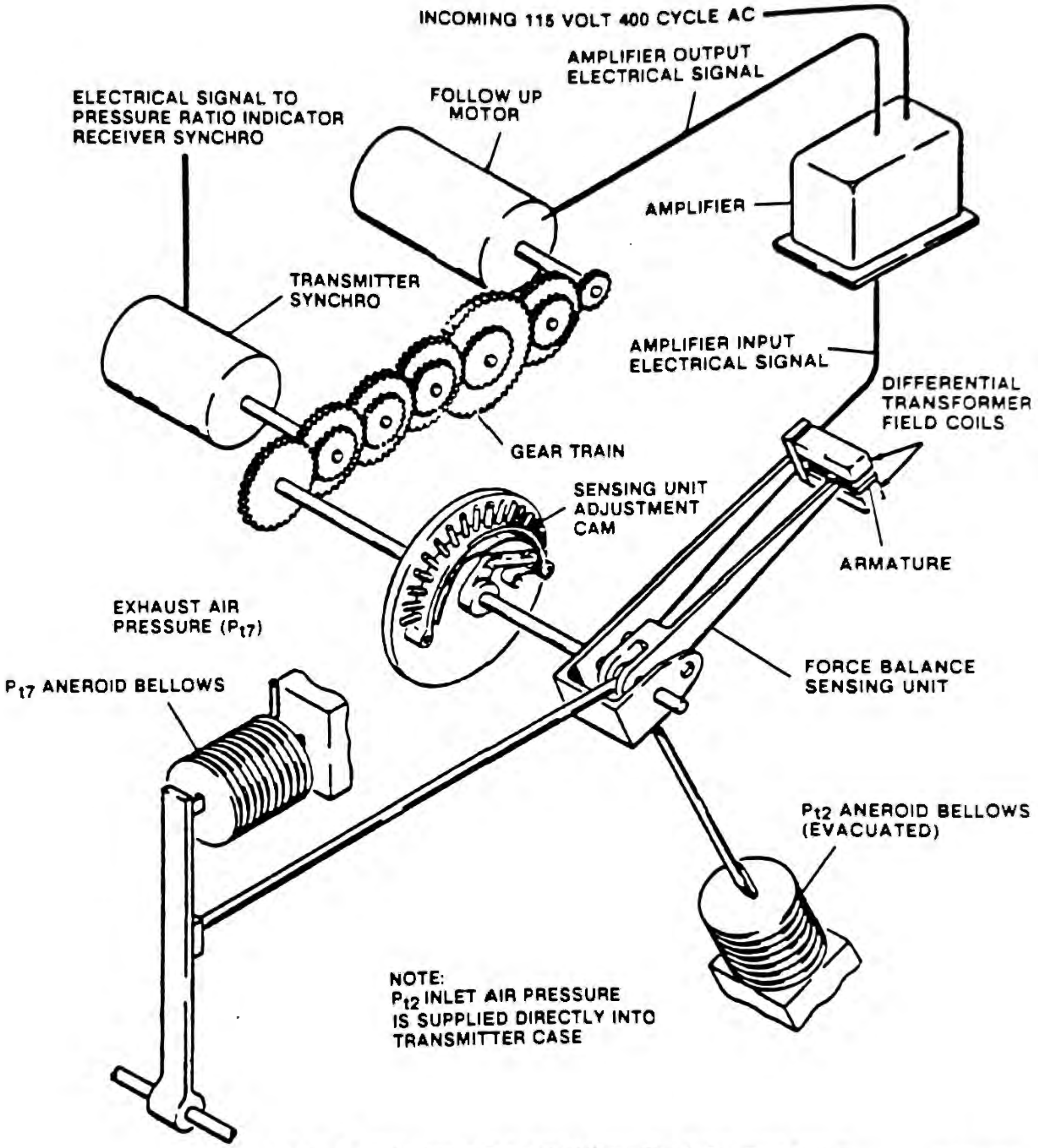
(4) When the fire extinguishing agent is discharged and the container pressure drops below a predetermined level, an extinguishing agent low-pressure indicating light comes on corresponding to the system selected.

(5) Returning the fire control handle to the normal position opens all the valves, but the generator field circuit remains open until reset.

21. Engine Indicating - Description and Operation

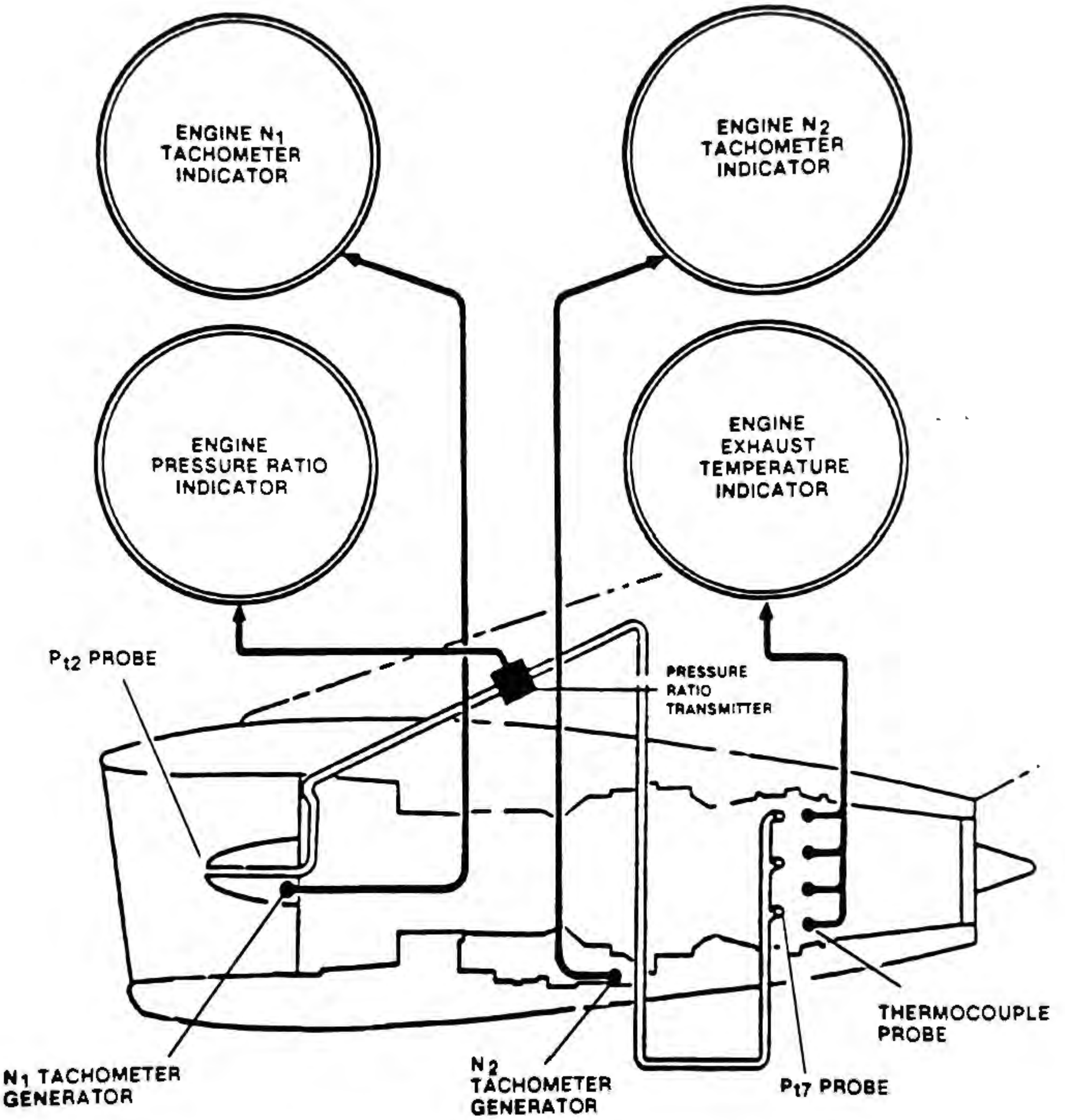
A. Description (See Figure 71-39)

(1) The engine indicating systems utilize pressures, compressor rotor speeds, and exhaust gas temperatures, to monitor engine operation. During engine operation, sensing devices located on each engine continuously transmit signals to instruments in the flight compartment which furnish indications of the engine operating condition.


INCOMING 115 VOLT 400 CYCLE AC
AMPLIFIER OUTPUT ELECTRICAL SIGNAL
ELECTRICAL SIGNAL TO PRESSURE RATIO INDICATOR RECEIVER SYNCHRO
FOLLOW UP MOTOR
AMPLIFIER
TRANSMITTER SYNCHRO
AMPLIFIER INPUT ELECTRICAL SIGNAL
DIFFERENTIAL TRANSFORMER FIELD COILS
GEAR TRAIN
SENSING UNIT ADJUSTMENT CAM
ARMATURE
EXHAUST AIR PRESSURE (P_{t7})
P_{t7} ANEROID BELLOWS
FORCE BALANCE SENSING UNIT
P_{t2} ANEROID BELLOWS (EVACUATED)
NOTE: P_{t2} INLET AIR PRESSURE IS SUPPLIED DIRECTLY INTO TRANSMITTER CASE

PRESSURE RATIO TRANSMITTER--SCHEMATIC FTX80582

Figure 71-41


ENGINE N_1 TACHOMETER INDICATOR
ENGINE N_2 TACHOMETER INDICATOR
ENGINE PRESSURE RATIO INDICATOR
ENGINE EXHAUST TEMPERATURE INDICATOR
P_{t2} PROBE
PRESSURE RATIO TRANSMITTER
THERMOCOUPLE PROBE
N_1 TACHOMETER GENERATOR
N_2 TACHOMETER GENERATOR
P_{t7} PROBE

ENGINE INDICATING SYSTEMS

FTX80580

Figure 71-39

(2) The engine indicating systems are divided into two categories: power, and temperature. The power portion consists of engine pressure ratio and the high- and low-pressure compressor rotor tachometer systems. The temperature portion consists of the exhaust gas temperature system.

(3) The engine pressure ratio system senses and measures differential pressure between compressor inlet air pressure and turbine exhaust gas pressure. Pressure ratio is displayed on an indicator in the flight compartment.

(4) Compressor rotor speeds are displayed on percentage-type indicators in the flight compartment. Each system derives its power from an engine-driven tachometer generator. Indications are provided for the low-pressure compressor rotor (N_1) and for the high-pressure compressor rotor (N_2).

(5) Engine exhaust gas temperature is sensed by six thermocouple probes mounted in the exhaust duct around the periphery of the engine. The exhaust gas temperature, averaged between the probes, is displayed on a null-balance-type indicator in the flight compartment.

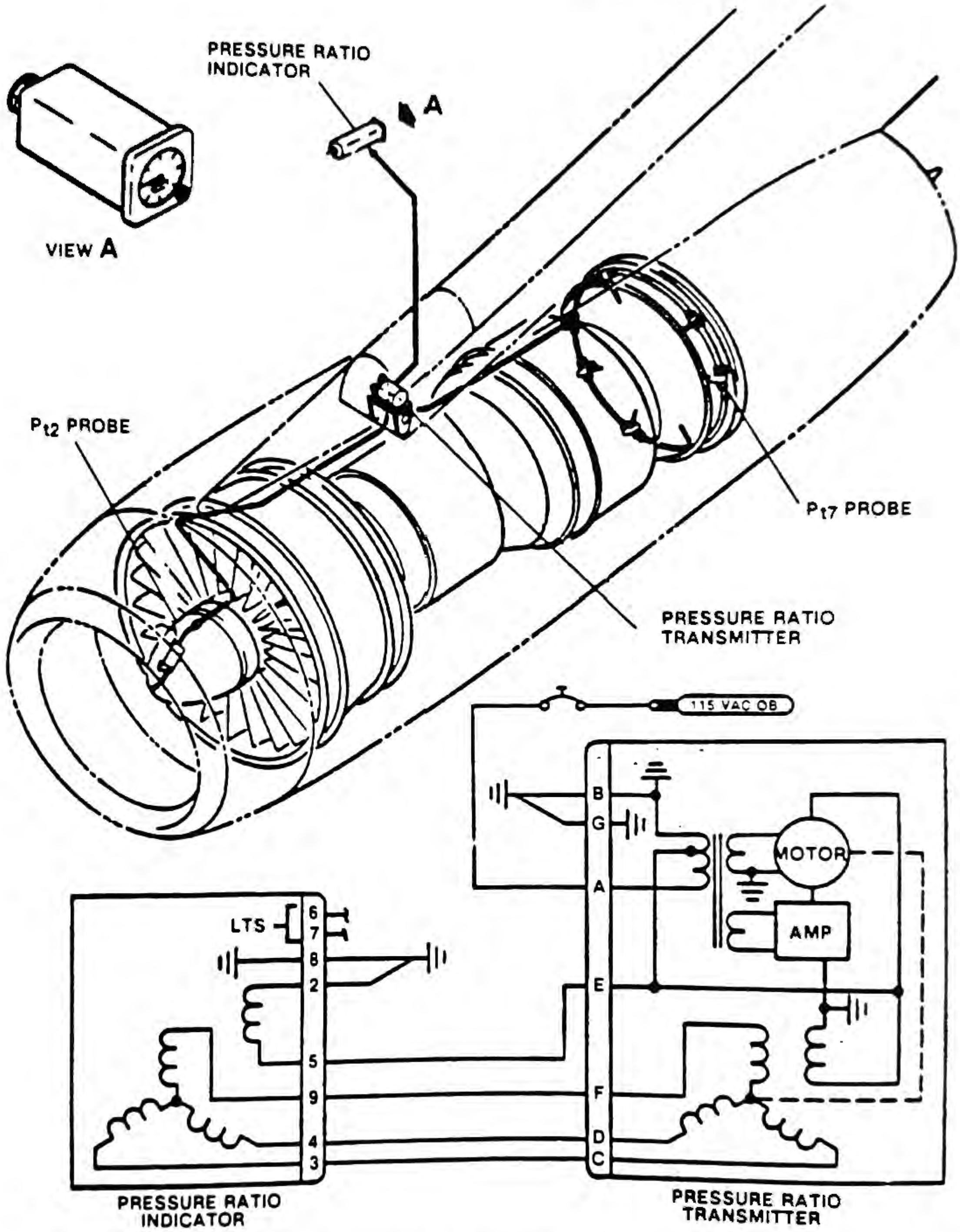
22. Power - Description and Operation

A. General

(1) Power indicating systems furnish a display of engine pressure ratios and compressor turbine speed which represent engine power output. The power indicating systems include the engine pressure ratio system, the low-pressure compressor (N_1) tachometer system, and the high-pressure compressor (N_2) system.

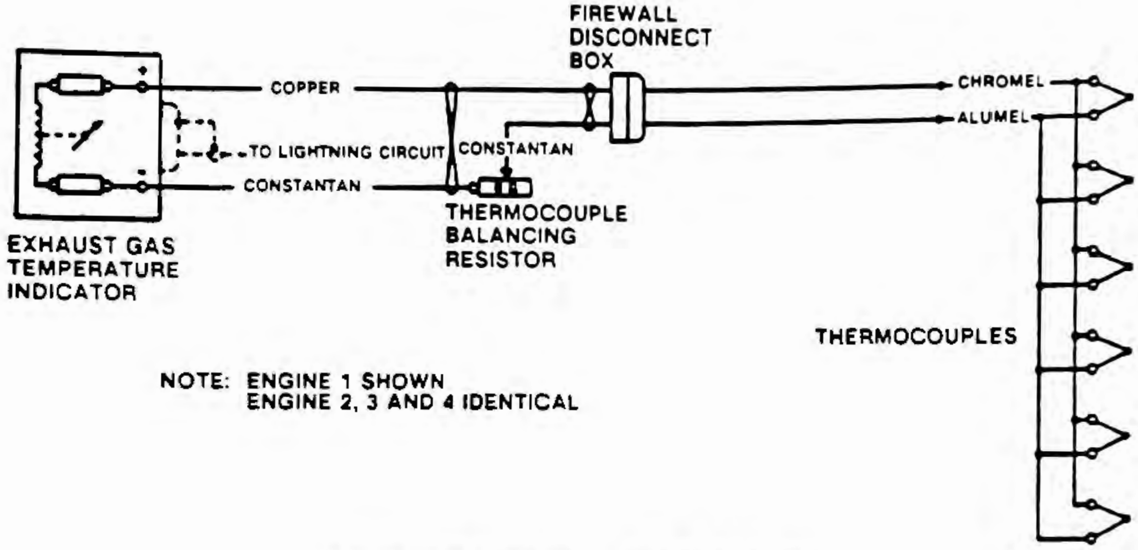
(2) The pressure ratio system consists of an inlet pressure-sensing probe (P_t2), six averaging total turbine exhaust pressure-sensing probes (P_t7), a transmitter, and an indicator.

(3) The low-pressure and high-pressure compressor rotor tachometer systems each consist of a tachometer generator and indicator.



PRESSURE RATIO SYSTEM -- SCHEMATIC FTX80581

Figure 71-40



TEMPERATURE -- SCHEMATIC

Figure 71-44

(4) The pressure ratio indicator is mounted in the flight compartment, and furnishes a dial indication of the ratio that exists between engine inlet and exhaust pressures. The indicator consists of a receiver synchro, dial and pointer, adjustable index bug and counter, and an external set knob. These components are housed in an integrally lighted, hermetically sealed case, provided with an external electrical connector.

(5) The inlet pressure-sensing probe (P_t2) is mounted in the inlet bullet and senses inlet total pressure. The probe protrudes through the forward end of the bullet and is an integral part of the unit.

(6) The six turbine exhaust probes (P_t7), mounted in the engine turbine exhaust case, sense exhaust total pressure. The probes are connected by a manifold which averages the pressure samplings. Tubing connects the manifold to the pressure ratio transmitter.

B. Operation (See Figure 71-41)

(1) In the static condition with no mechanical force exerted on the transmitter P_t2 or P_t7, aneroid bellows, the force balance sensing unit armature is in a null (or balanced) position, centered between the two transformer field coils. When the airplane electrical buses are energized and pressures are supplied by an operating engine or, during functional test of system by an outside pressure source, the inlet and exhaust gas pressure exert force on the P_t2 and P_t7 aneroid bellows. This force, transmitted through the force balance sensing unit, controls the armature of the differential transformer. Changing the position of the armature unbalances the transformer and applies a phase -sensitive input signal to the amplifier. The amplifier output signal, energizes the followup motor to drive the gear train which in turn rotates the transmitter synchro to a new null by repositioning the armature between the differential transformer field coils. When a null exists, the followup motor stops and the synchro electrical signal is relayed to the receiver synchro in the indicator. The receiver synchro drives the pointer to a dial position which represents a numerical value of pressure ratio.

(2) By adjusting the indicator external set knob, the index bug and counter can be positioned to a desired pressure ratio reference setting for visual comparison with the actual indicated pressure ratio.

24. Tachometer Systems - Description and Operation

A. General (See Figure 71-42)

(1) Each engine has two tachometer systems to measure the rotational speeds of the high-speed and the low-speed compressors. Rotation of the high-speed compressor is measured by the N_2 tachometer system and the rotation of the low-speed compressor is measured by the N_1 tachometer system. Each system consists of an engine-mounted tachometer generator and an indicator installed in the flight compartment.

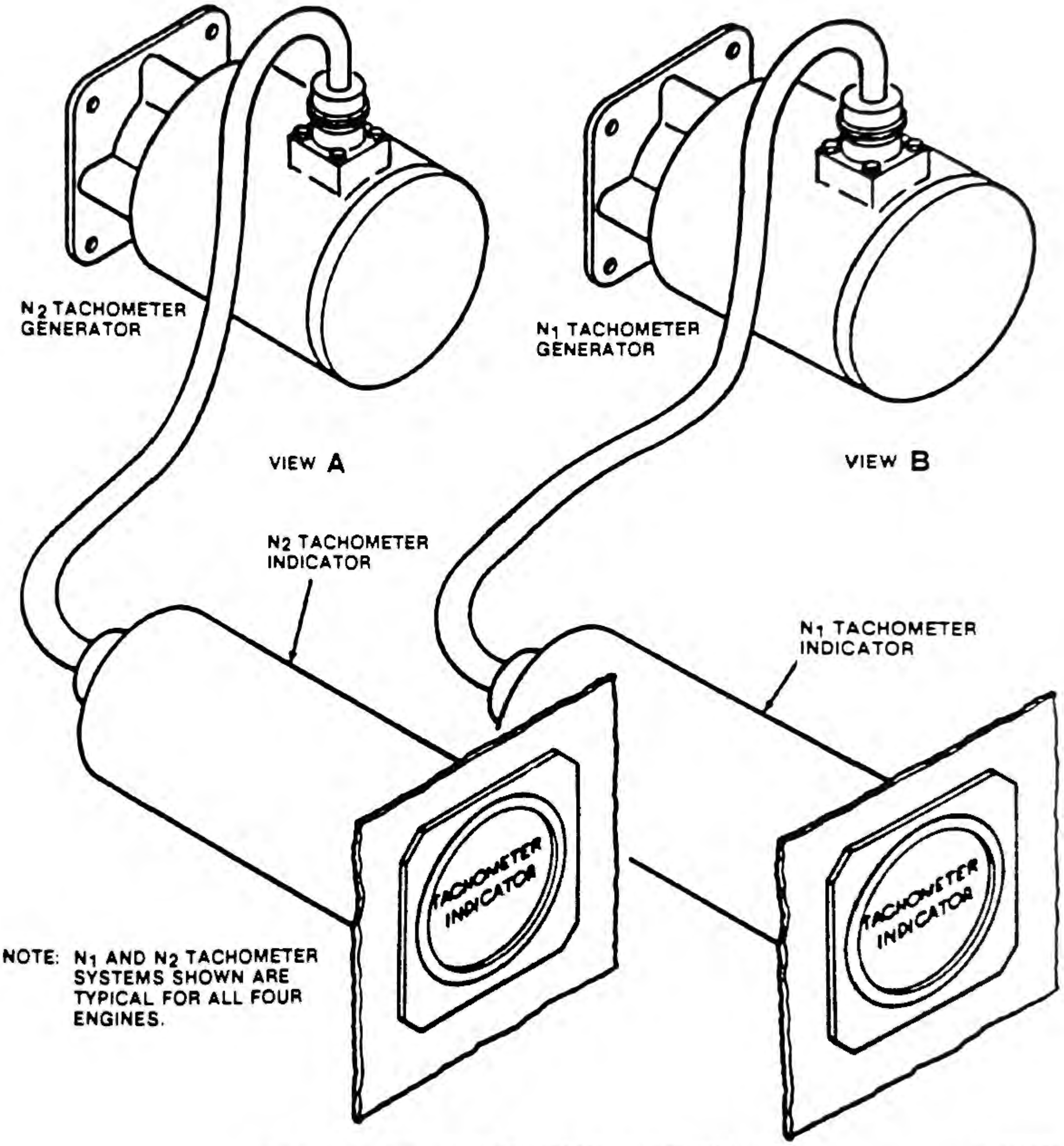
(2) The tachometer generator is a two-pole, three-phase unit that is pad-mounted on either the lower or the forward accessory drive case. The tachometer generator consists of a permanent-magnet type rotor, a stator, and a housing which includes a mounting flange that is compatible with either drive pad.

(3) The tachometer indicator is a hermetically sealed unit, which consists of a synchronous motor, a magnetic coupling, and an indicating mechanism. The synchronous motor is driven by signals produced by the tachometer generator. A torque proportional to the compressor rotational speed is applied to the indicating mechanism through the magnetic coupling. The indicator is integrally lighted.

B. Operation

(1) The tachometer generator creates a frequency signal as it is driven by the compressor through the accessory drive. Increase or decrease in compressor rotor speed proportionally increases or decreases the frequency output of the generator.

(2) The frequency output of the tachometer generator energizes the synchronous motor of the tachometer indicator, causing it to run at a speed proportional to the compressor rotor speed. Torque from the synchronous motor is transmitted through the magnetic coupling to the indicator pointer mechanism, which displays the torque as the percentage of compressor rotor maximum rpm.

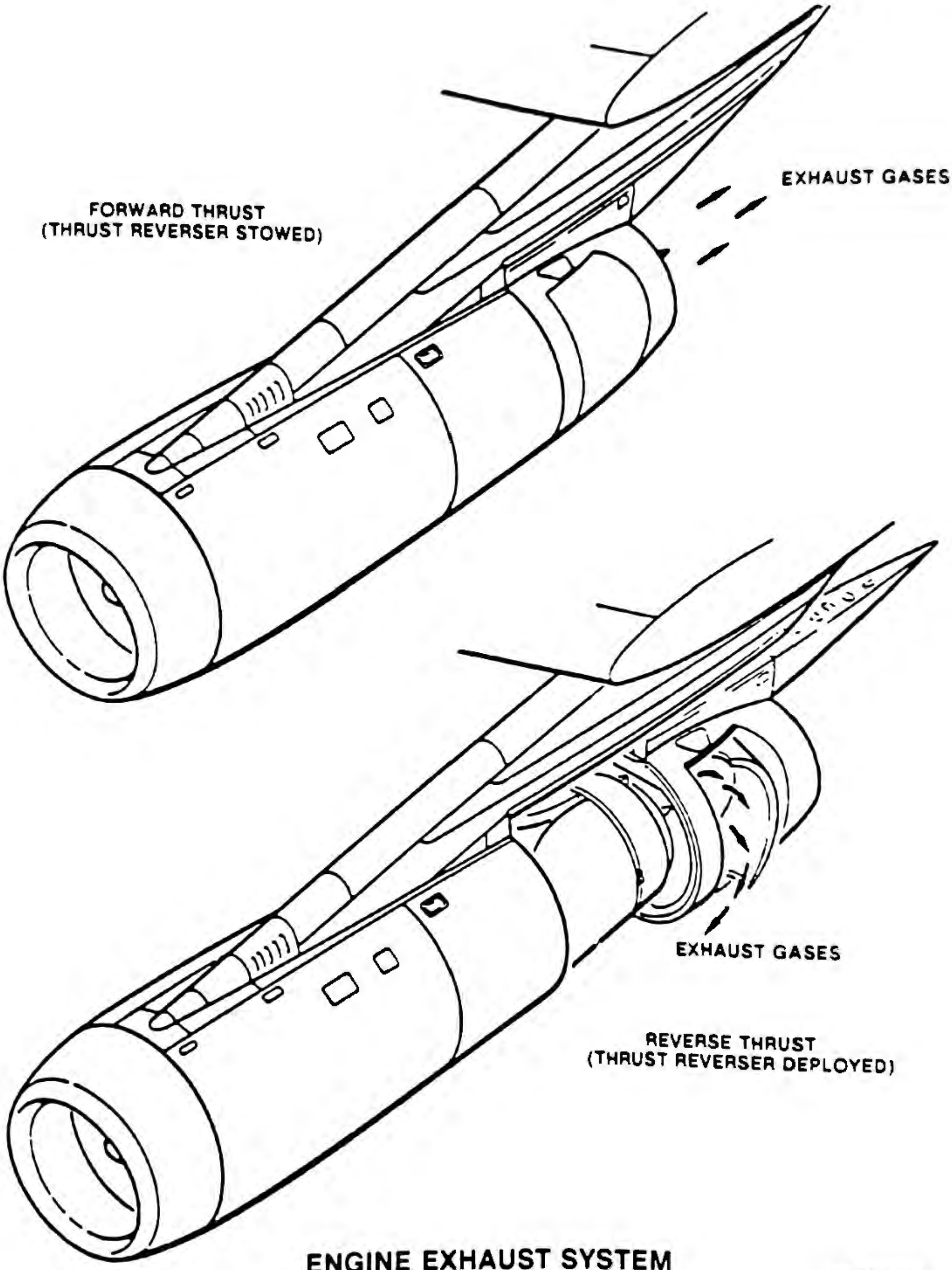


NOTE: N1 AND N2 TACHOMETER SYSTEMS SHOWN ARE TYPICAL FOR ALL FOUR ENGINES.

TACHOMETER SYSTEMS -- SCHEMATIC

FTX80583

Figure 71-42



ENGINE EXHAUST SYSTEM

FTX80587

Figure 71-46

25. Temperature - Description and Operation

A. General (See Figures 71-43 & 71-44)

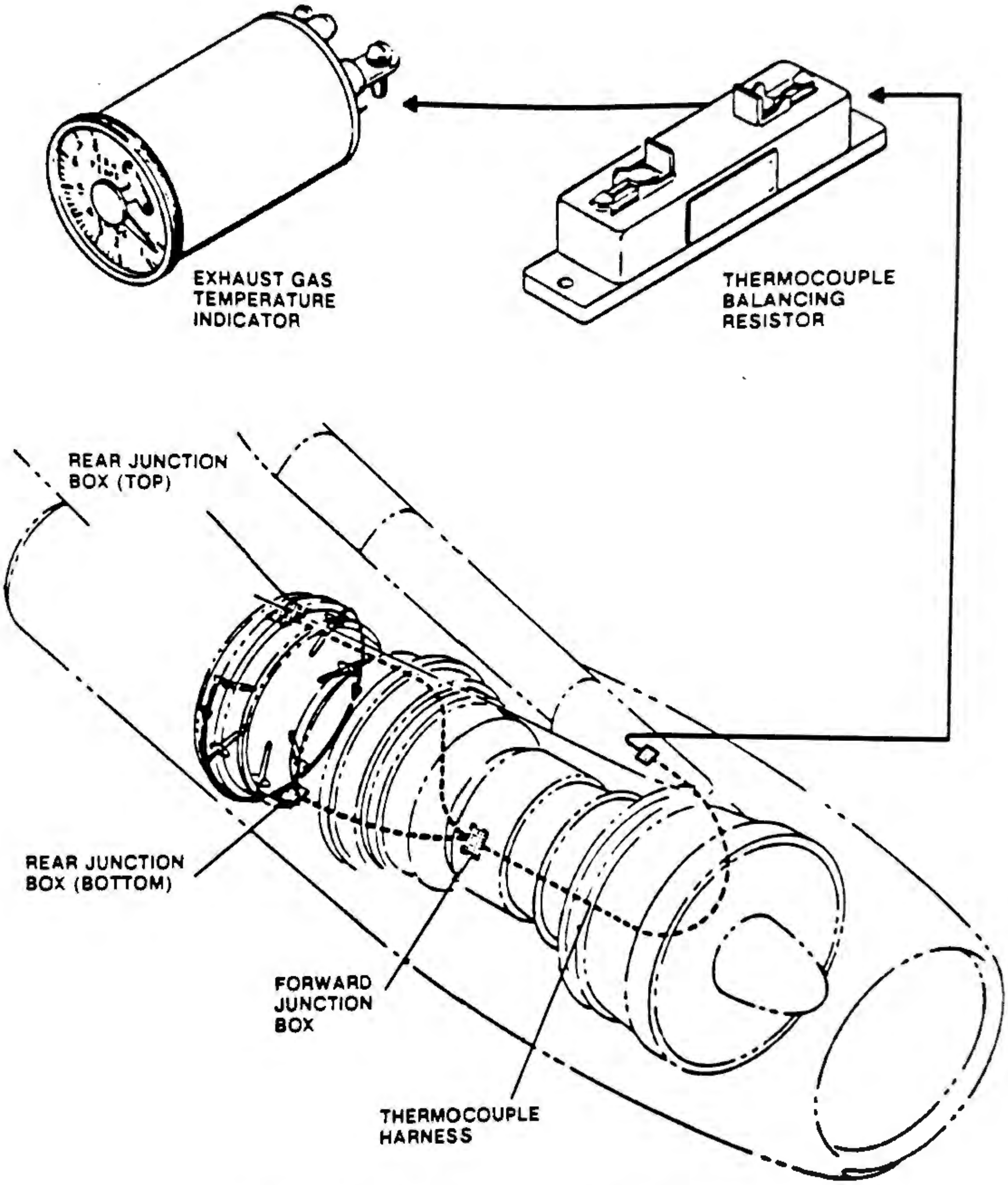
(1) The engine exhaust gas temperature (EGT) system consists of an exhaust gas temperature indicator, a thermocouple balancing resistor, six thermocouple probes, an averaging harness, and a thermocouple test receptacle.

(2) The exhaust gas temperature indicators are located on the engine instrument panel in the flight compartment.

(3) The thermocouple balancing resistors (see Figure 71-45) are located on the electrical power center forward equipment panel. The resistors provide the means for adjustment of the external EGT resistance. The EGT system is designed to operate with a total resistance of 21.95 to 22.05 ohms at approximately 21°C (70°F) ambient temperature. Each thermocouple balancing resistor contains resistance wire which is adjusted during system calibration to provide the proper total system resistance.

(4) The thermocouple probes are mounted on the turbine exhaust case. The thermocouple probes consist of two thermocouple junctions within a common sampling-type probe. One thermocouple junction is connected to the averaging harness and the other junction is used for individual readings. The thermocouple junctions are connected to studs at the top of the probe. Both junctions and studs are made of chromel and alumel material. The nut and stud diameters of the alumel terminals are larger than those of the chromel terminals. Each thermocouple has exhaust gas inlet and discharge holes.

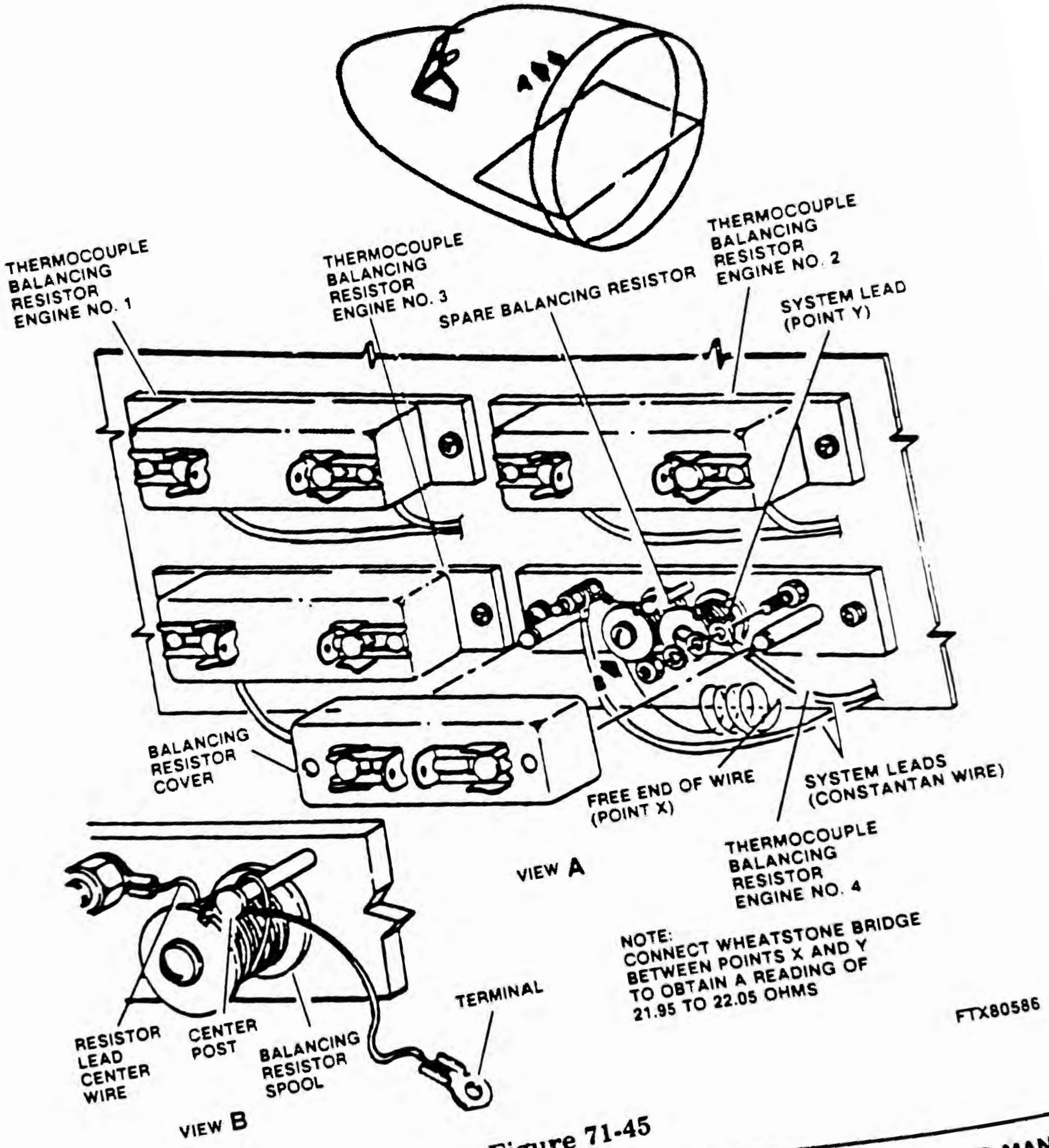
(5) The averaging harness provides a means of conveying the resultant samplings of the thermocouple probes to a common connection. The harness is mounted on the outer circumference of the turbine case and consists of six pairs of thermocouple wire encased in a heat-resistant shielded wire casing. Two electrical connectors from the harness are provided. One connector is attached to the averaging lead, located on the upper left side of the engine, which connects into the engine electrical wiring harness. The second connector is the thermocouple test connector, located on the right side of the engine. The test connector provides a means of individually testing each thermocouple probe.


EXHAUST GAS TEMPERATURE INDICATOR
THERMOCOUPLE BALANCING RESISTOR
REAR JUNCTION BOX (TOP)
REAR JUNCTION BOX (BOTTOM)
FORWARD JUNCTION BOX
THERMOCOUPLE HARNESS

TEMPERATURE -- SCHEMATIC

FTX80584

Figure 71-43


THERMOCOUPLE BALANCING RESISTOR ENGINE NO. 1
THERMOCOUPLE BALANCING RESISTOR ENGINE NO. 3
SPARE BALANCING RESISTOR
THERMOCOUPLE BALANCING RESISTOR ENGINE NO. 2
SYSTEM LEAD (POINT Y)
B
BALANCING RESISTOR COVER
FREE END OF WIRE (POINT X)
SYSTEM LEADS (CONSTANTAN WIRE)
THERMOCOUPLE BALANCING RESISTOR ENGINE NO. 4
VIEW A
RESISTOR LEAD CENTER WIRE
CENTER POST
BALANCING RESISTOR SPOOL
TERMINAL
VIEW B
FTX80586

NOTE:
CONNECT WHEATSTONE BRIDGE BETWEEN POINTS X AND Y TO OBTAIN A READING OF 21.95 TO 22.05 OHMS

Figure 71-45

bottom of the engine at the duct aft end. Four splitter webs are mounted internally in each duct to direct the flow of air through the duct and to provide additional supporting strength.

(6) The primary exhaust nozzle fan air duct is a circular shaped aluminum alloy section approximately 15 inches long, surrounding the aft end of the primary exhaust nozzle. Eight splitter webs are mounted internally in the duct to direct the flow of air through the duct and to provide supporting strength to the duct. The aft end of the aft fan air ducts are fastened to this duct by means of bolts. Bolted strap halves with seal are installed around the primary exhaust nozzle and aft fan air duct mating joint to provide an air seal.

C. Engine Exhaust Collector

The collector for the engine turbine and exhaust section consists of the primary exhaust nozzle and a strut and bullet assembly. The primary exhaust nozzle is bolted to the engine turbine and exhaust section and provides the proper exhaust exit area to produce optimum engine operation. A strut and bullet assembly is mounted internally, and bolted in the aft end of the primary exhaust nozzle. The strut and bullet assembly directs the flow of exhaust gases from the engine and provides additional supporting strength to the primary nozzle. The primary exhaust nozzle fan air duct is permanently attached to the primary exhaust nozzle.

28. Thrust Reverser - Description and Operation

A. General (See Figure 71-49)

The engine thrust reverser system provides a means for reducing the aircraft speed during landing operations and under certain conditions of flight. The thrust reverser system consists of a translating ring and deflector doors assembly, translating ring support tracks, actuating and control system, emergency control system, and indicating system.

B. Operation

Heating of the thermocouple probes during engine operation creates a small current in the dissimilar metals of the thermocouple probe proportional to the temperature of the engine exhaust gas. The thermocouple probes are connected in parallel, which averages the heat-generated current. This average current is supplied to the deflecting coil of the indicator. The amount of current in the deflecting coil determines the amount of pointer deflection and the exhaust gas temperature reading on the dial.

26. Exhaust Nozzle - Description and Operation

A. Description (See Figures 71-46 & 71-47)

The exhaust nozzle, and fan air ducts comprise the major portion of the exhaust system. The airplane is equipped with four completely independent target-type thrust reverser systems. Each system is mechanically, electrically, and pneumatically controlled and hydraulically powered.

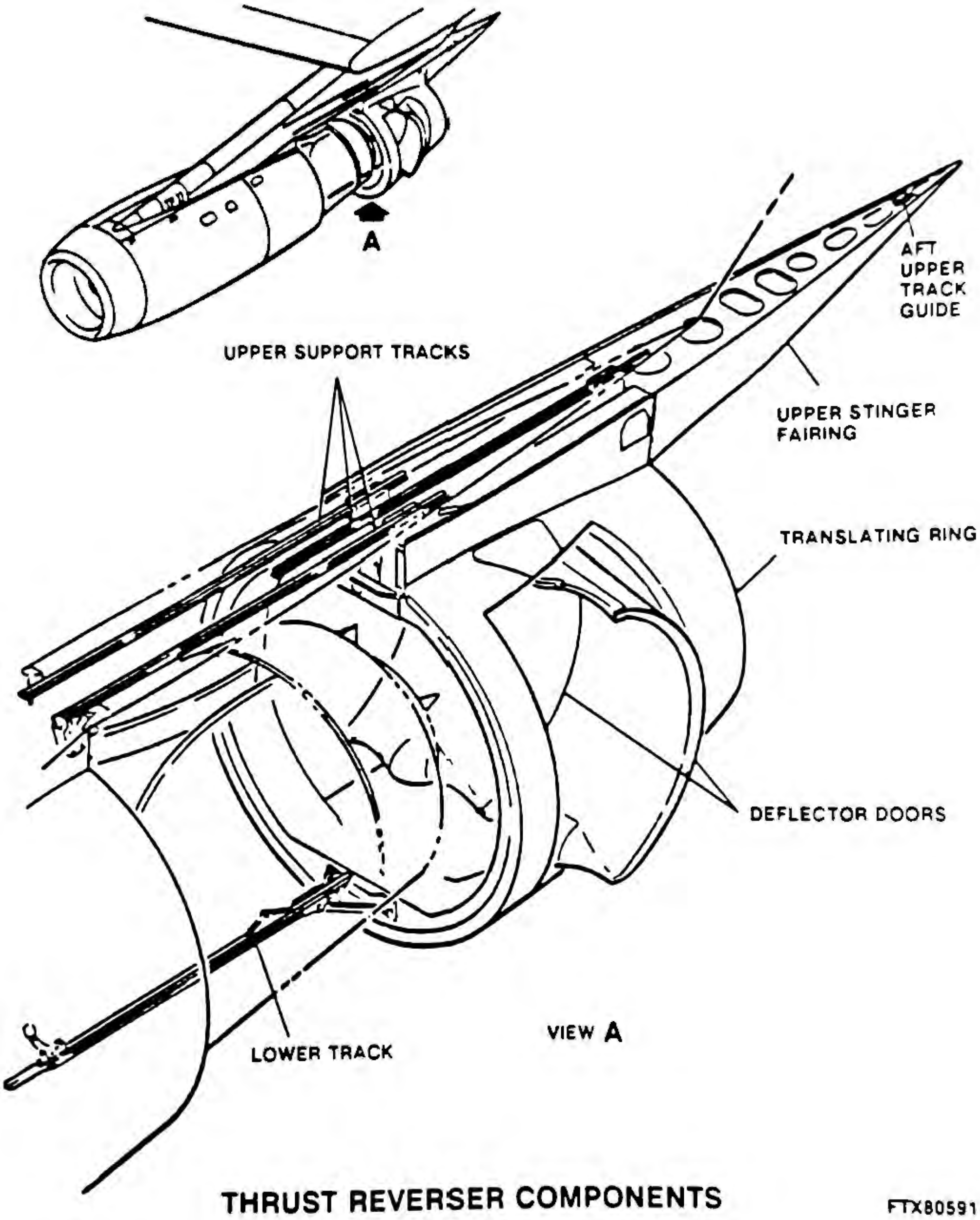
27. Collector - Description and Operation

A. General

The collector system consists of the engine fan air ducting and the engine turbine and exhaust section. During engine operation, the exhaust fan air and the engine exhaust gases join at the rear of the engine, aft of the thrust reverser, with the thrust reverser in the stowed position.

B. Engine Fan Air Collector (See Figure 71-48)

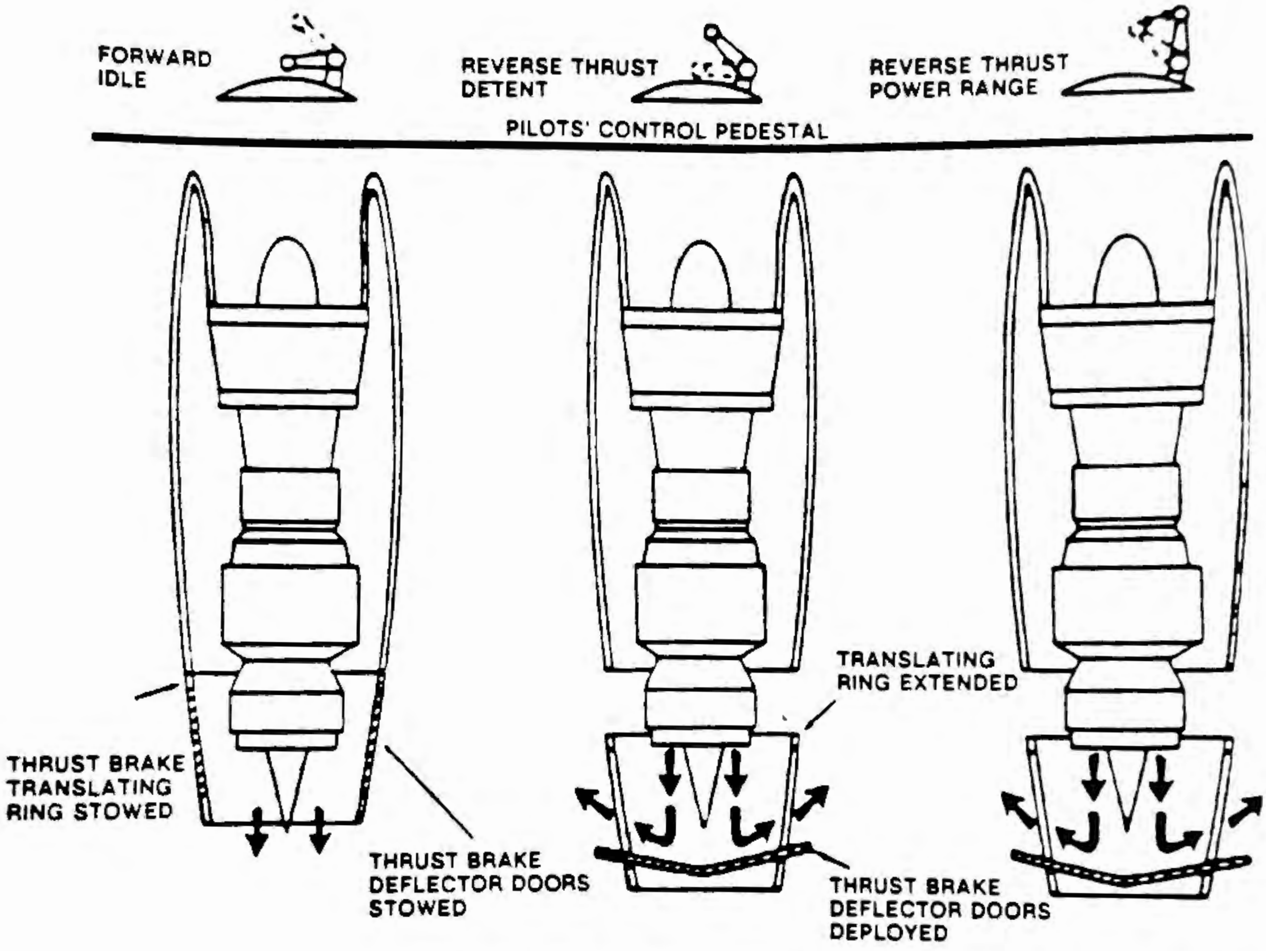
(1) The engine fan air collector consists of four ducts on each side of the engine and a duct attached to the primary exhaust nozzle. The side ducts are constructed of bonded aluminum alloy and aluminum honeycomb, and are interchangeable, right and left. The ducts are from front to rear, the forward bifurcated fan air duct, hinged constant section fan air duct, transition section fan air duct, aft fan air duct, and primary exhaust nozzle fan air duct.



THRUST REVERSER COMPONENTS

FTX80591

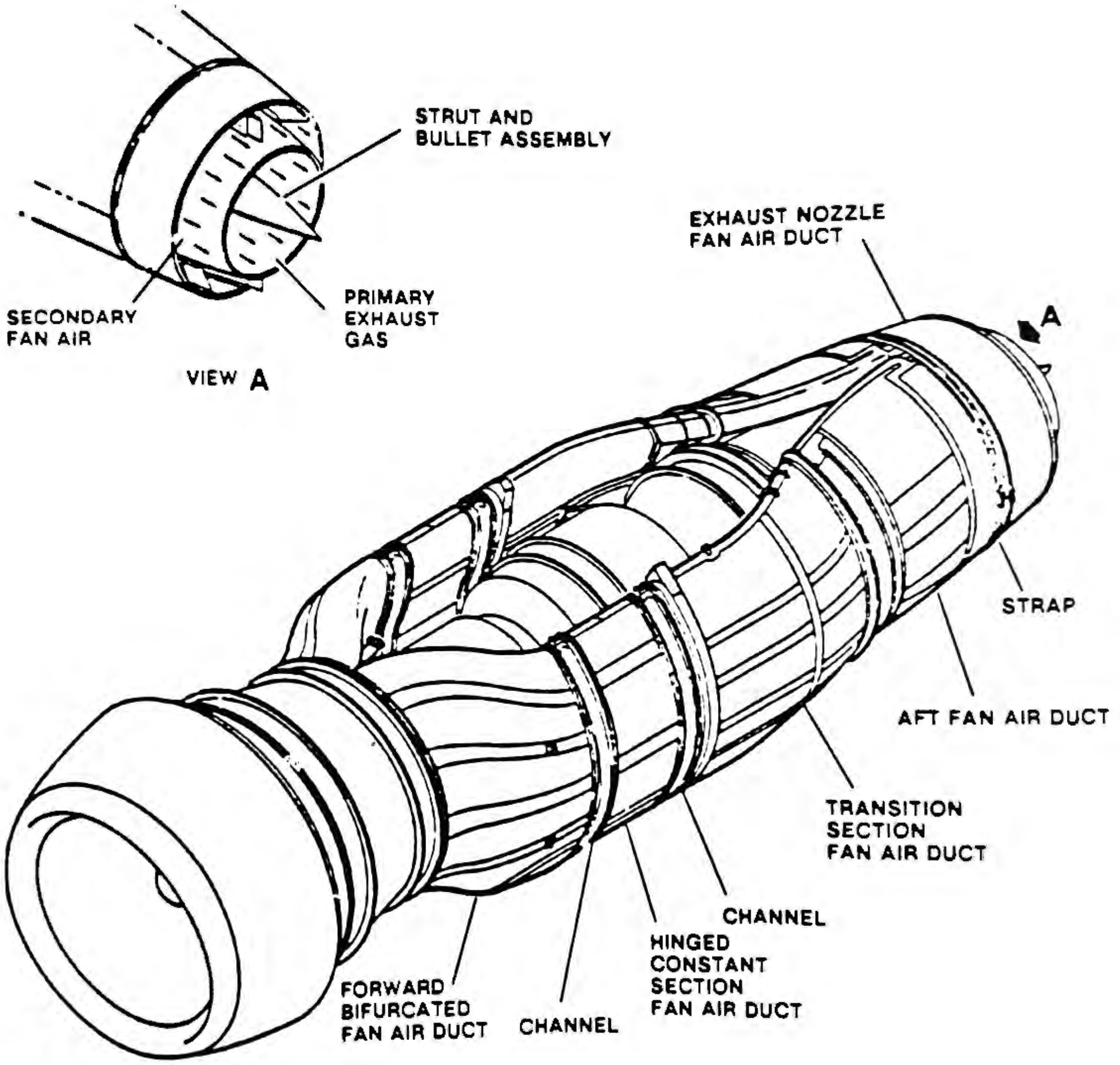
Figure 71-50


FORWARD IDLE
REVERSE THRUST DETENT
REVERSE THRUST POWER RANGE
PILOTS' CONTROL PEDESTAL
TRANSLATING RING EXTENDED
THRUST BRAKE TRANSLATING RING STOWED
THRUST BRAKE DEFLECTOR DOORS STOWED
THRUST BRAKE DEFLECTOR DOORS DEPLOYED

ENGINE THRUST -- SCHEMATIC

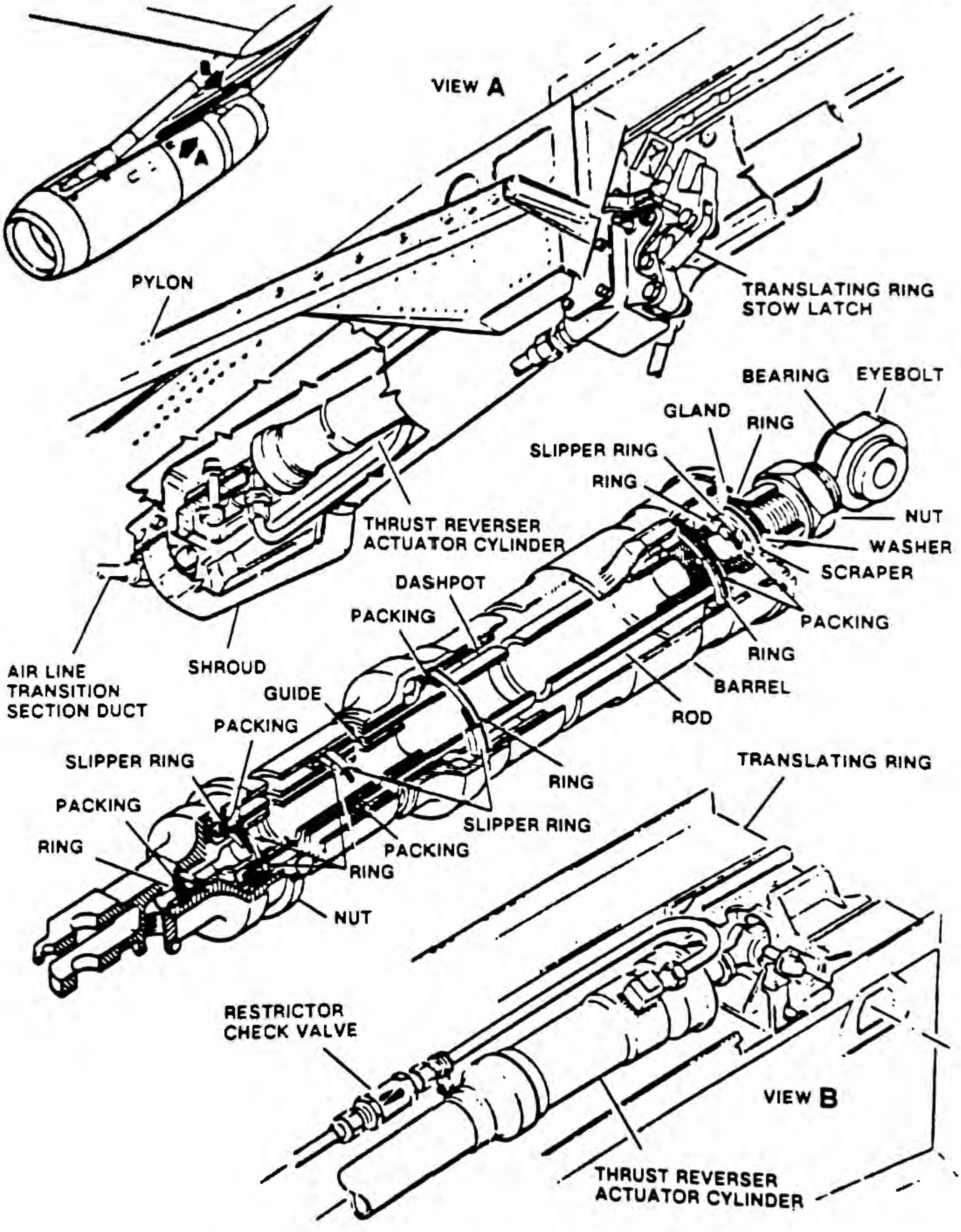
FTX80588

Figure 71-47



FAN AIR AND EXHAUST COLLECTOR SYSTEM FTX80589

Figure 71-48



THRUST REVERSER ACTUATOR CYLINDER FTX80593

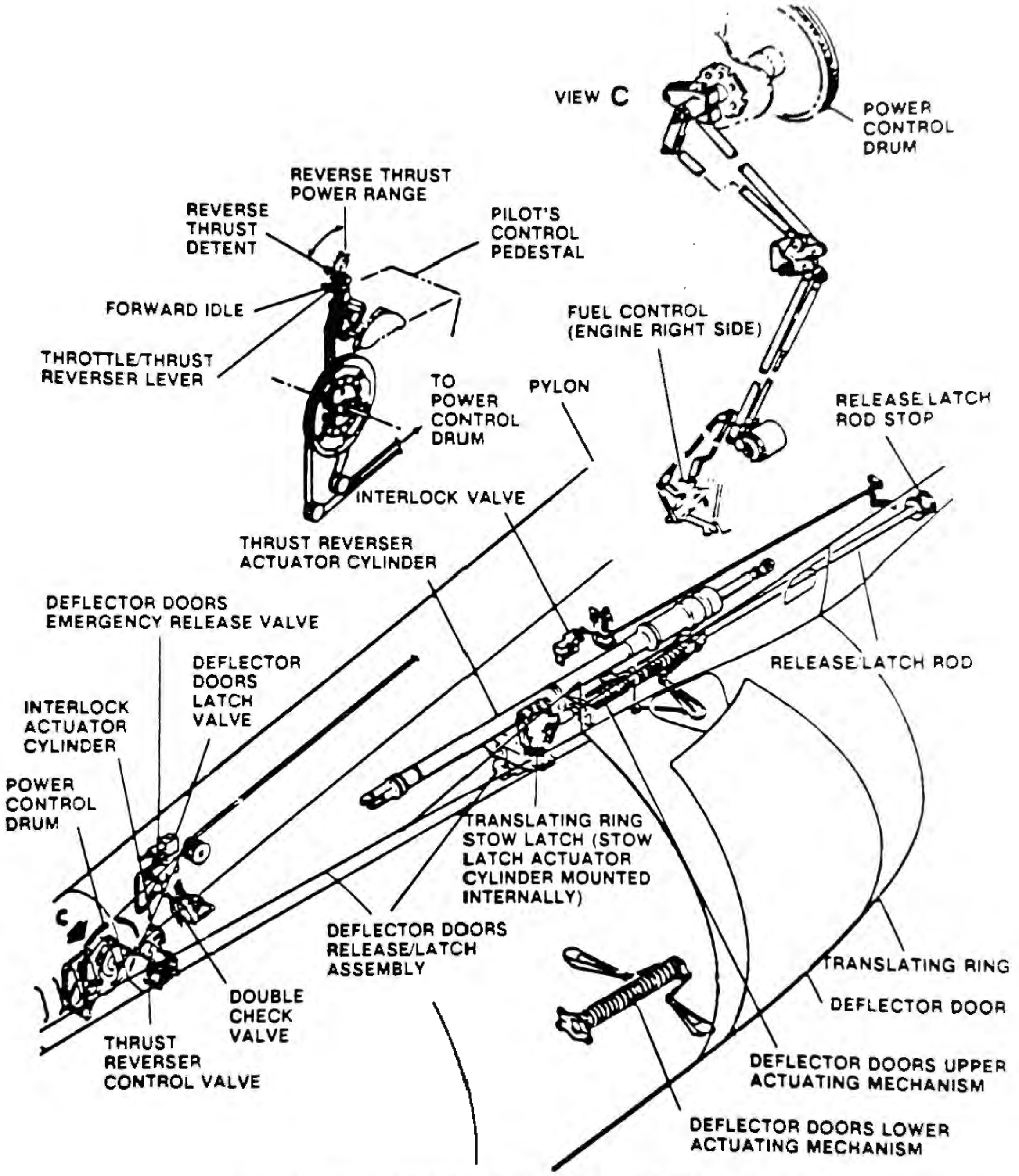
Figure 71-52

(2) The forward bifurcated fan air ducts are installed between the engine fan exhaust exit and the hinged constant section fan air ducts. Each bifurcated duct has a semi-circular shape at the forward end to match the shape of the fan exhaust exit. The ducts are bolted to the aft face of the fan exhaust exit and are contoured at the aft end to fit the side of the engine. The aft end of the duct is fastened to the hinged constant section fan air duct with bolted channel assemblies, which clamp the ends of the ducts together. Five splitter webs are attached to the inner surface of each duct to direct the flow of air through the duct and to provide additional supporting strength.

(3) The hinged constant section fan air ducts are installed between the forward bifurcated fan air ducts and the transition section fan air ducts. The ducts are contoured to fit the side of the engine at the compressor section. The ducts are fastened to the aft end of the forward bifurcated fan air ducts and to the front end of the transition section fan air ducts, with bolted channel assemblies, two on each side. These channel assemblies are hinged at the top with pins. By removing the two bolts from the upper and lower end of each channel assembly, the channels can be rotated outward and upward. Three splitter webs are mounted internally in each duct to direct the flow of air through the duct and to provide additional strength.

(4) The transition section fan air ducts are installed between the hinged constant section fan air ducts and the aft fan air ducts. The ducts are contoured to fit the side of the engine and are attached at the burner section by three rods on each side. The ducts are attached at the forward end to the hinged constant section fan air ducts with bolted channel assemblies which clamp the ends of the ducts together. The aft end of the transition section fan air ducts are fastened to the aft fan air ducts by means of bolts. Four splitter webs are mounted internally in each duct to direct the flow of air through the duct and to provide additional supporting strength.

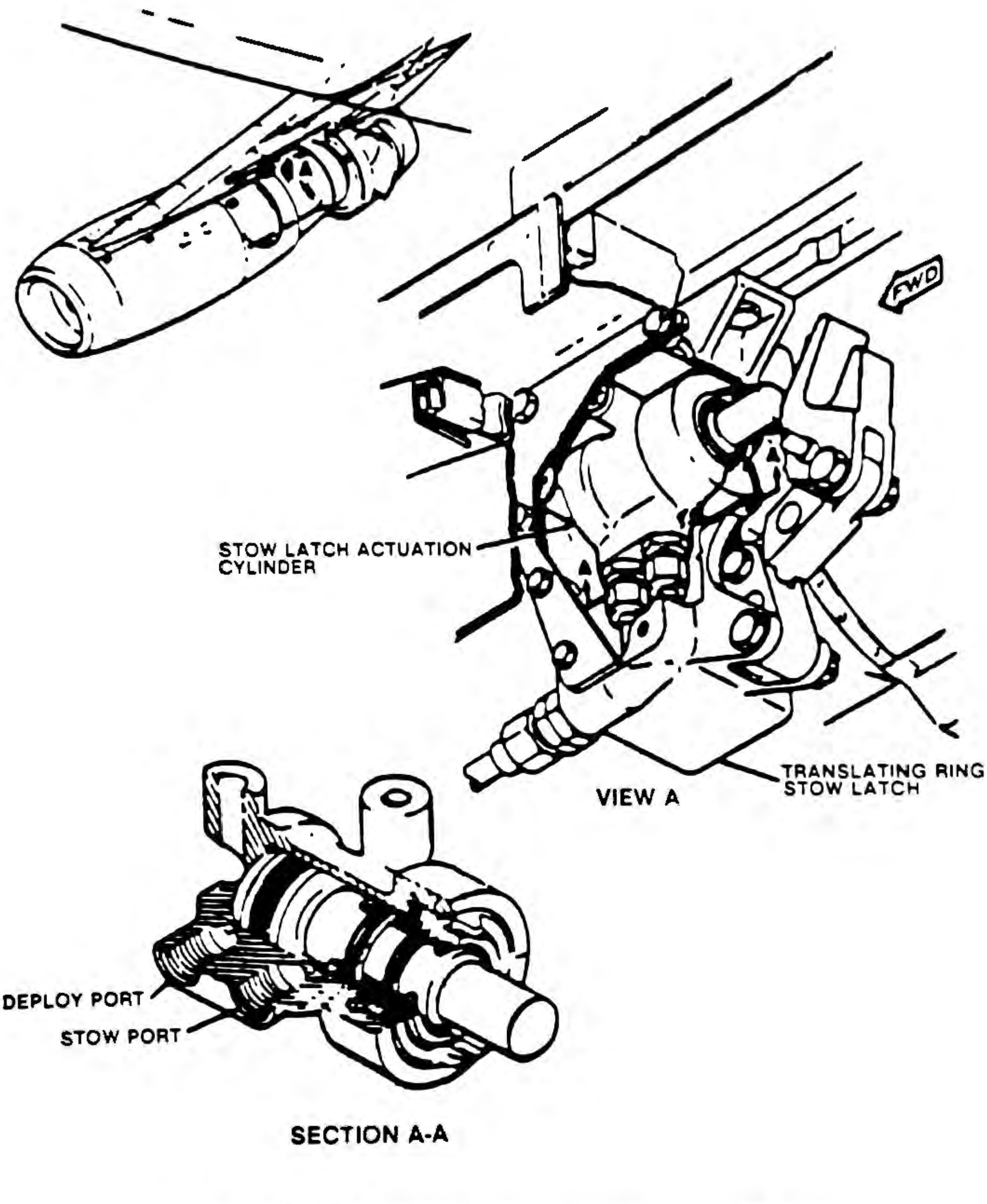
(5) The aft fan air ducts are installed between the transition Section Fan air ducts and the primary exhaust nozzle fan air duct. The ducts are attached to the aft end of the transition section fan air ducts by means of bolts. The aft end of the fan air ducts are fastened to the primary exhaust nozzle fan air duct with bolts. The ducts are semi-circular in shape to conform to the forward face of the primary exhaust nozzle fan air duct, with the two ducts meeting at the top and


VIEW C
POWER CONTROL DRUM
REVERSE THRUST POWER RANGE
REVERSE THRUST DETENT
PILOT'S CONTROL PEDESTAL
FORWARD IDLE
THROTTLE/THRUST REVERSER LEVER
FUEL CONTROL (ENGINE RIGHT SIDE)
TO POWER CONTROL DRUM
PYLON
RELEASE LATCH ROD STOP
INTERLOCK VALVE
THRUST REVERSER ACTUATOR CYLINDER
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
DEFLECTOR DOORS LATCH VALVE
RELEASE LATCH ROD
INTERLOCK ACTUATOR CYLINDER
POWER CONTROL DRUM
C
TRANSLATING RING STOW LATCH (STOW LATCH ACTUATOR CYLINDER MOUNTED INTERNALLY)
DEFLECTOR DOORS RELEASE/LATCH ASSEMBLY
TRANSLATING RING
DEFLECTOR DOOR
DOUBLE CHECK VALVE
THRUST REVERSER CONTROL VALVE
DEFLECTOR DOORS UPPER ACTUATING MECHANISM
DEFLECTOR DOORS LOWER ACTUATING MECHANISM

THRUST REVERSER SYSTEM COMPONENTS

FTX80590

Figure 71-49



TRANSLATING RING STOW LATCH & ACTUATOR CYLINDER

Figure 71-55

B. Translating Ring and Deflector Doors (See Figure 71-50)

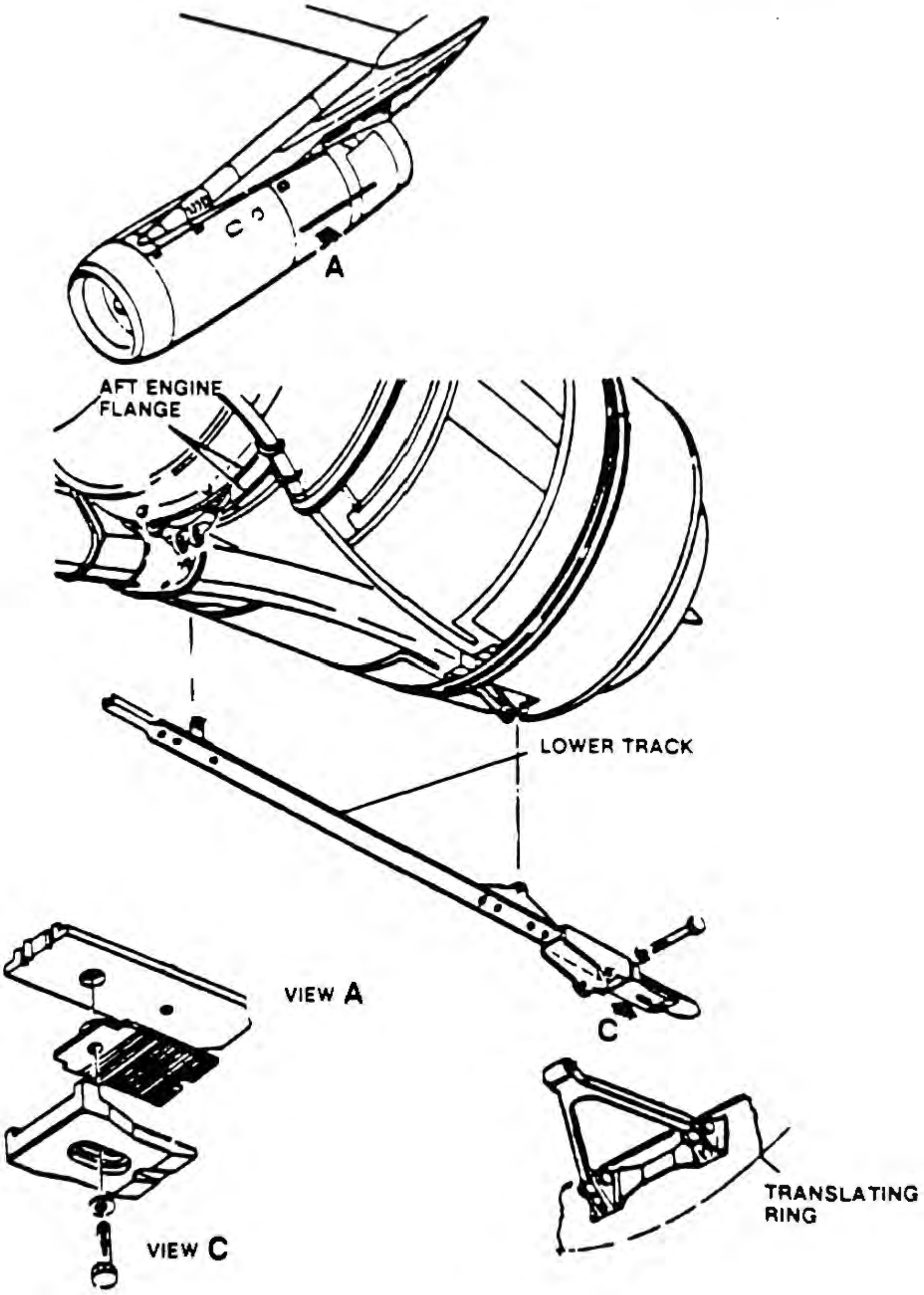
(1) The translating ring supports and provides a means for placing the deflector doors in the engine exhaust stream when reverse thrust is required. The translating ring is fabricated from aluminum and titanium and consists of a moveable sleeve which encompasses the engine exhaust nozzle. In the stowed position the ring forward edge is against the aft edge of the engine aft cowl. In the full aft position the ring forward edge is approximately opposite the trailing edge of the exhaust nozzle.

(2) Two deflector doors are installed in each translating ring for deflecting engine exhaust. The doors are constructed of corrosion resistant steel and are installed, one on each side of the translating ring vertical centerline. Each door is hinged on a vertical center such that in the stowed position each door fairs with the interior and exterior of the translating ring. Rotated to the deployed position, the trailing edge of the doors come together and form a seal for blocking the flow of exhaust gases.

C. Translating Ring Support Tracks (See Figures 71-50 & 71-51)

(1) Three translating ring upper support tracks of equal length are attached to the aft underside of the pylon structure. The tracks are staggered with the center track placed to the rear of the outer tracks. The center track incorporates a retainer at the aft end which serves as a stop when performing maintenance practices.

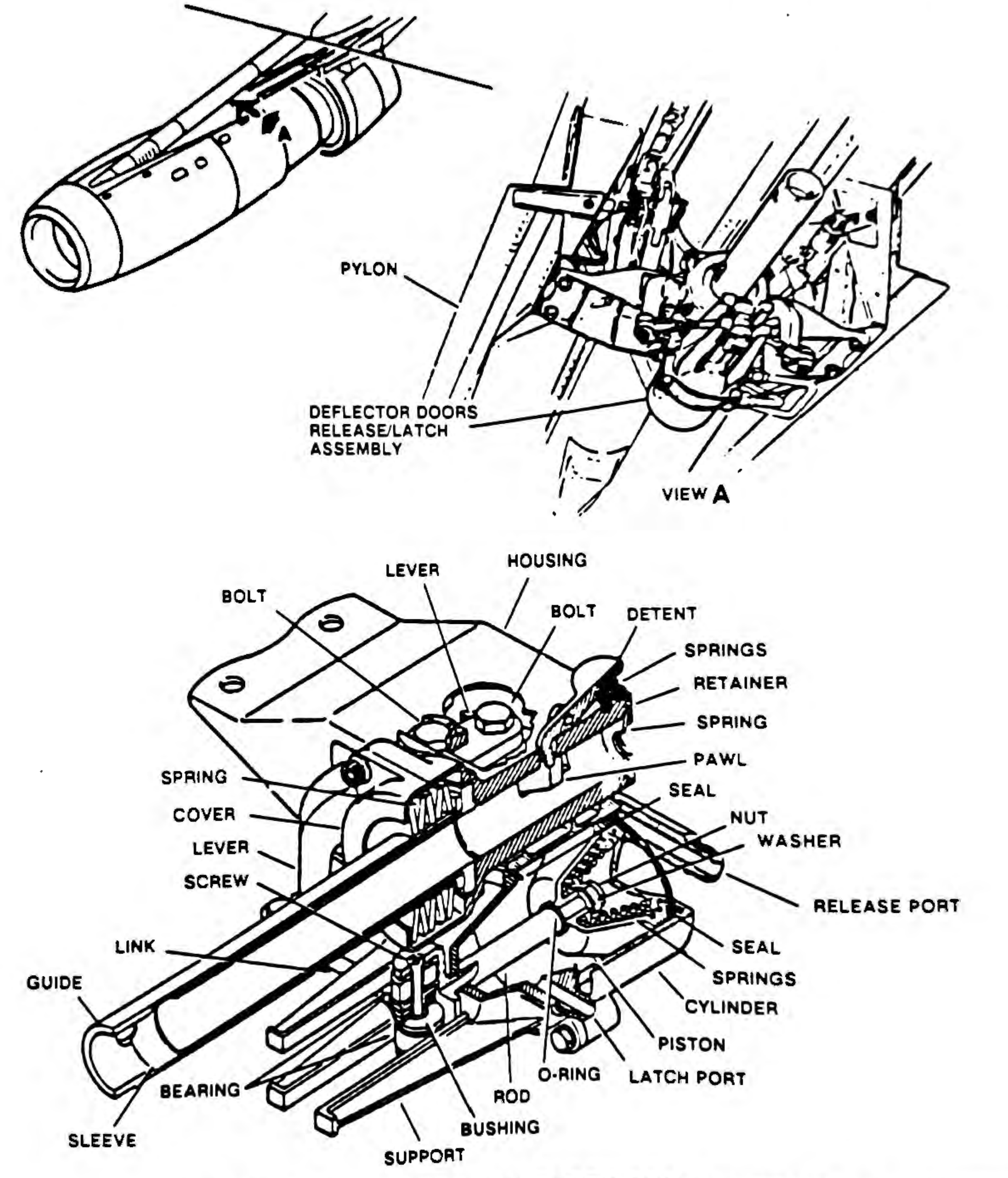
(2) The translating ring lower track is attached to the underside of the aft mount flange, and to the exhaust nozzle fan duct. The track is supported at the forward end by means of a yoke fitting and two rod end bearings which are bolted to the engine aft mount flange. A mount fitting attached to the forward end of the track is bolted to the yoke fitting. A forged fitting is bolted to the bottom of the primary exhaust nozzle and is attached to a mount fitting fastened to the aft end of the track. A stop is installed at the aft end of the track, to prevent the slider which is attached to the translating ring, from sliding off the end of the track.



LOWER TRACK ASSEMBLY

FTX80592

Figure 71-51



DEFLECTOR DOORS RELEASE/LATCH ASSEMBLY FTX80596

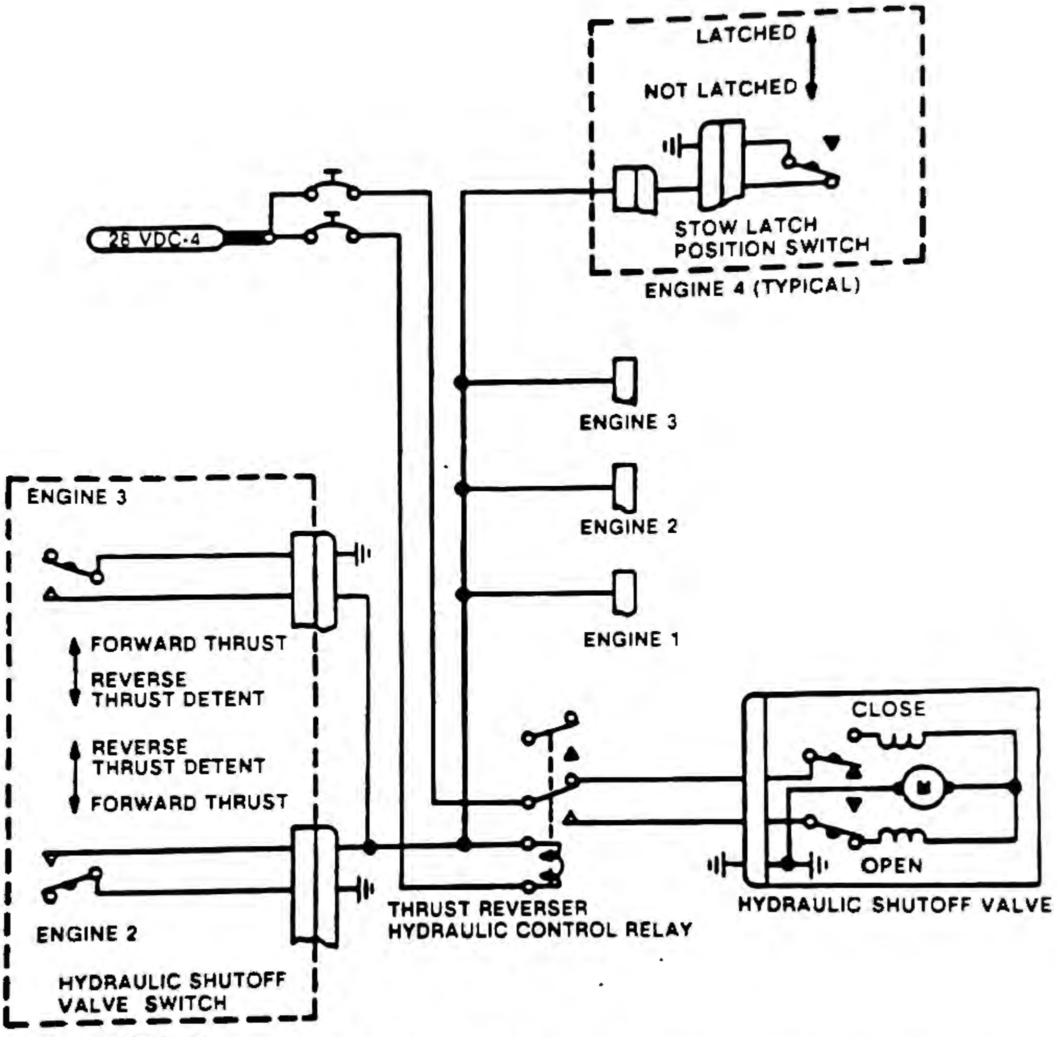
Figure 71-57

D. Thrust Reverser Actuating and Control System

(1) The thrust reverser actuating and control system includes the thrust reverser actuator cylinder, deflector doors upper and lower actuating mechanism, deflector doors release/latch assembly, rod, and stop. translating ring stow latch, stow latch actuator cylinder, thrust reverser control valve, hydraulic shutoff valve, deflector doors latch valve, emergency release valve, and double check valve.

(2) The thrust reverser actuator cylinder (see Figure 71-52) is a double acting hydraulic cylinder, which is connected to the pylon and translating ring and used to extend and retract the translating ring. The cylinder is located on the bottom of the pylon above the engine rear mounts, enclosed in a shroud for cooling purposes. The cylinder consists of a rod, guide, dashpot, head, gland, barrel assembly, eyebolt assembly, scraper, backup rings, retainer ring and washer, packings. and attaching parts. The gland is installed on the aft end of the barrel assembly, the head is installed at the forward end, both parts being threaded to the barrel. The dashpot is installed in the larger diameter of the barrel aft end. The dashpot cushions the actuator cylinder rod to prevent slamming of the translating ring and deflector doors, by controlling the escaping hydraulic fluid during the last few inches of cylinder rod travel. The rate is progressively decreased. The dashpot also provides an increased piston area during the first seven inches of thrust reverser retraction to fair the deflector doors. The forward end of the actuator cylinder is bolted to the pylon structure. The actuator cylinder rod is bolted to the aft upper side of the translating ring. The retracted length of the actuator cylinder is approximately 75 inches. The stroke of the actuator cylinder is approximately 52 inches.

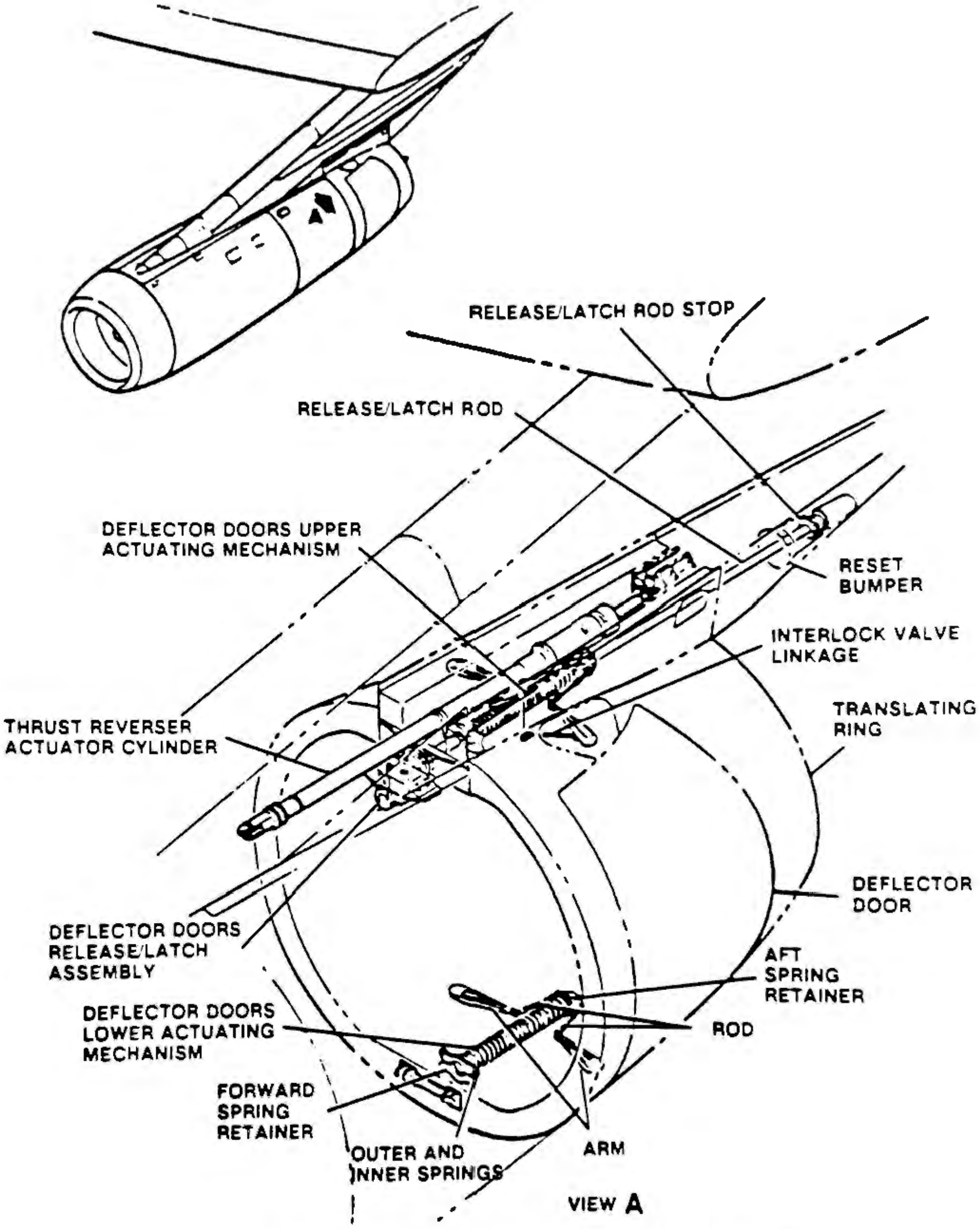
(3) The deflector doors actuating mechanism (see figures 71-53 & 71-54) consists of two linkage and arm assemblies attached to the upper and lower structures of the deflector doors. The upper assembly consists of a fitting, slider, spacer, inner and outer springs, two rods, two arms, and attaching parts. The lower assembly consists of a forward spring retainer, aft spring retainer, tube, guide tube aft support, inner and outer springs, spring spacer, two rods, two arms and attaching parts.



THRUST REVERSER HYDRAULIC SHUTOFF VALVE CONTROL -- SCHEMATIC

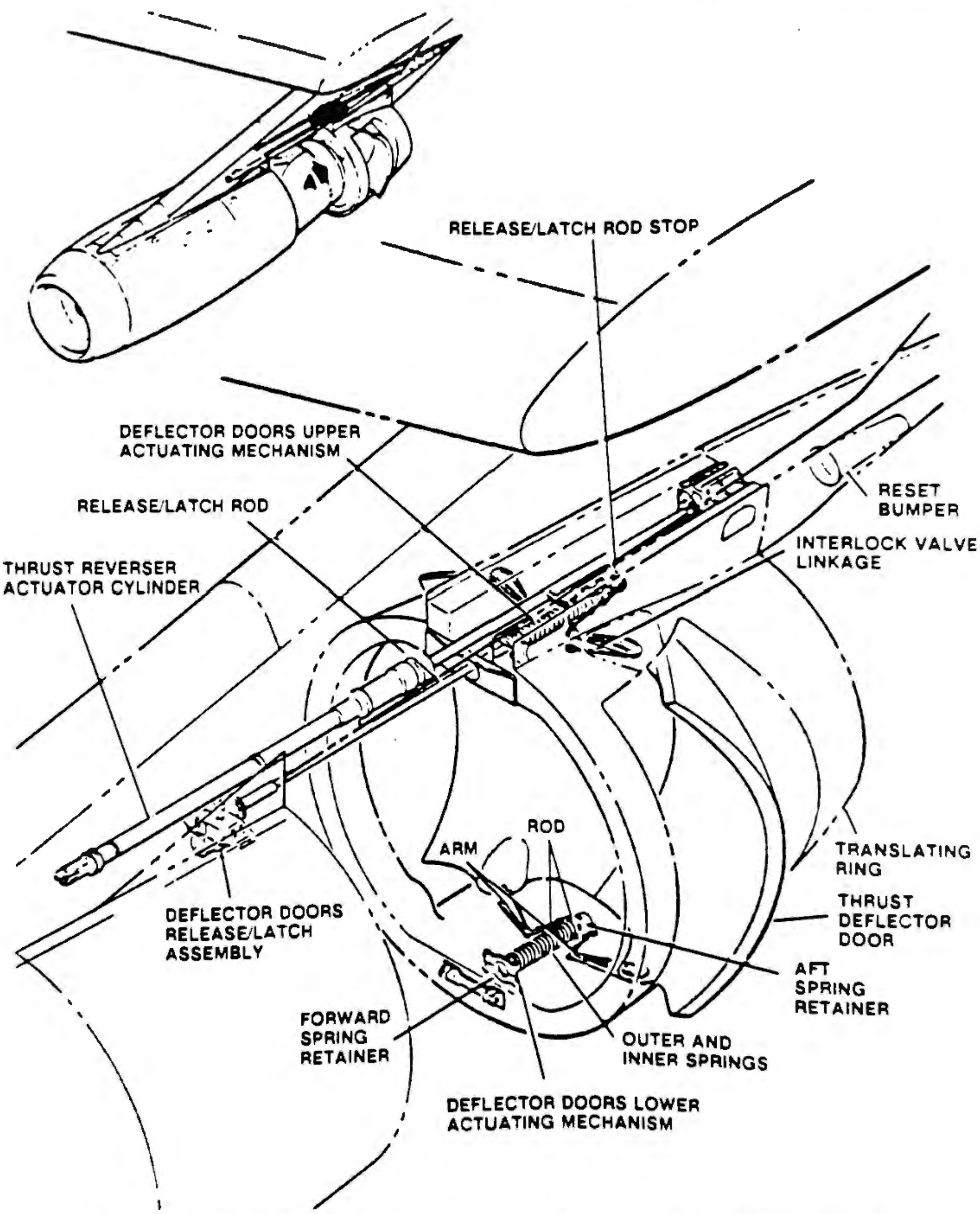
FTX80603

Figure 71-59

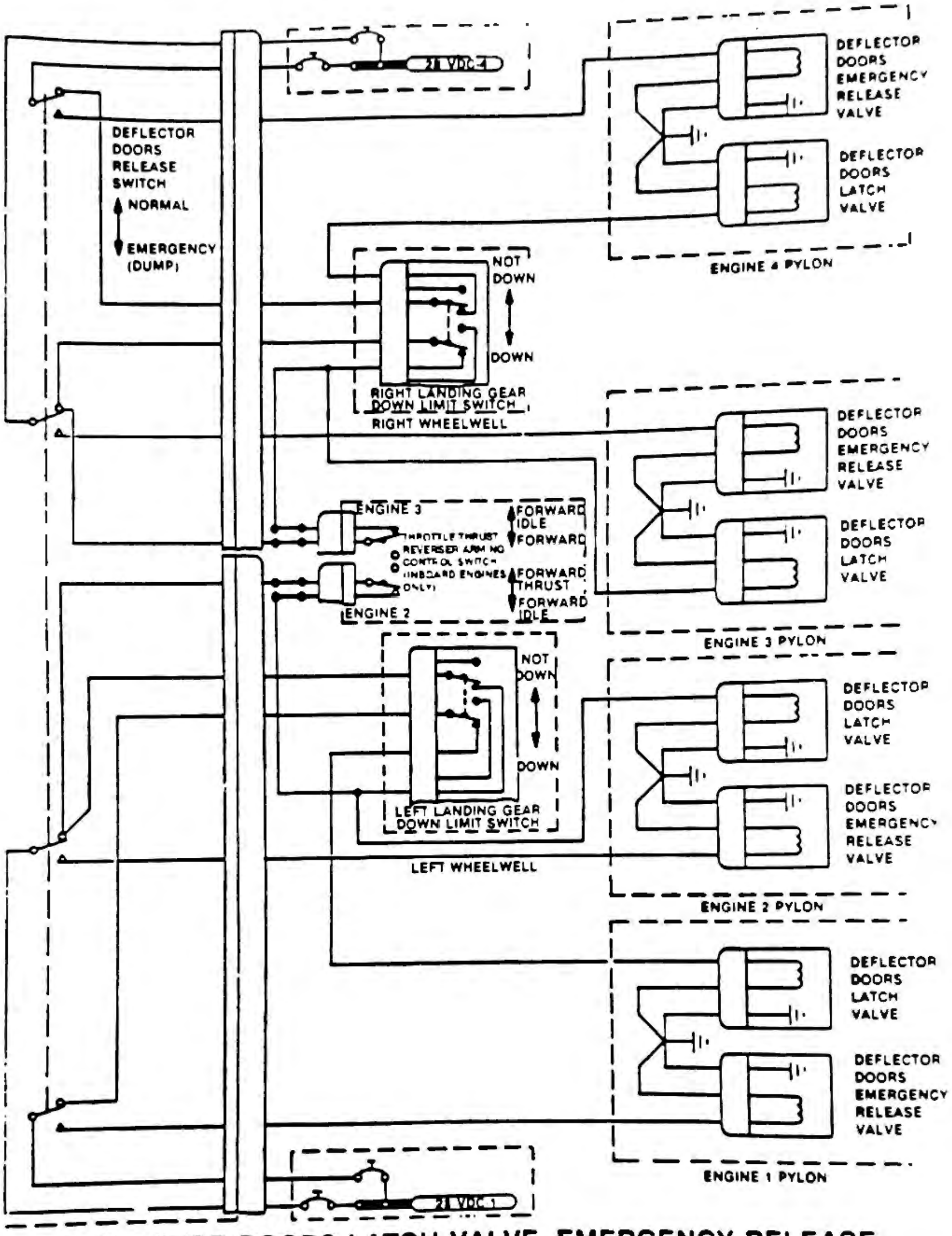


DEFLECTOR DOORS ACTUATING MECHANISM STOWED FTX80594

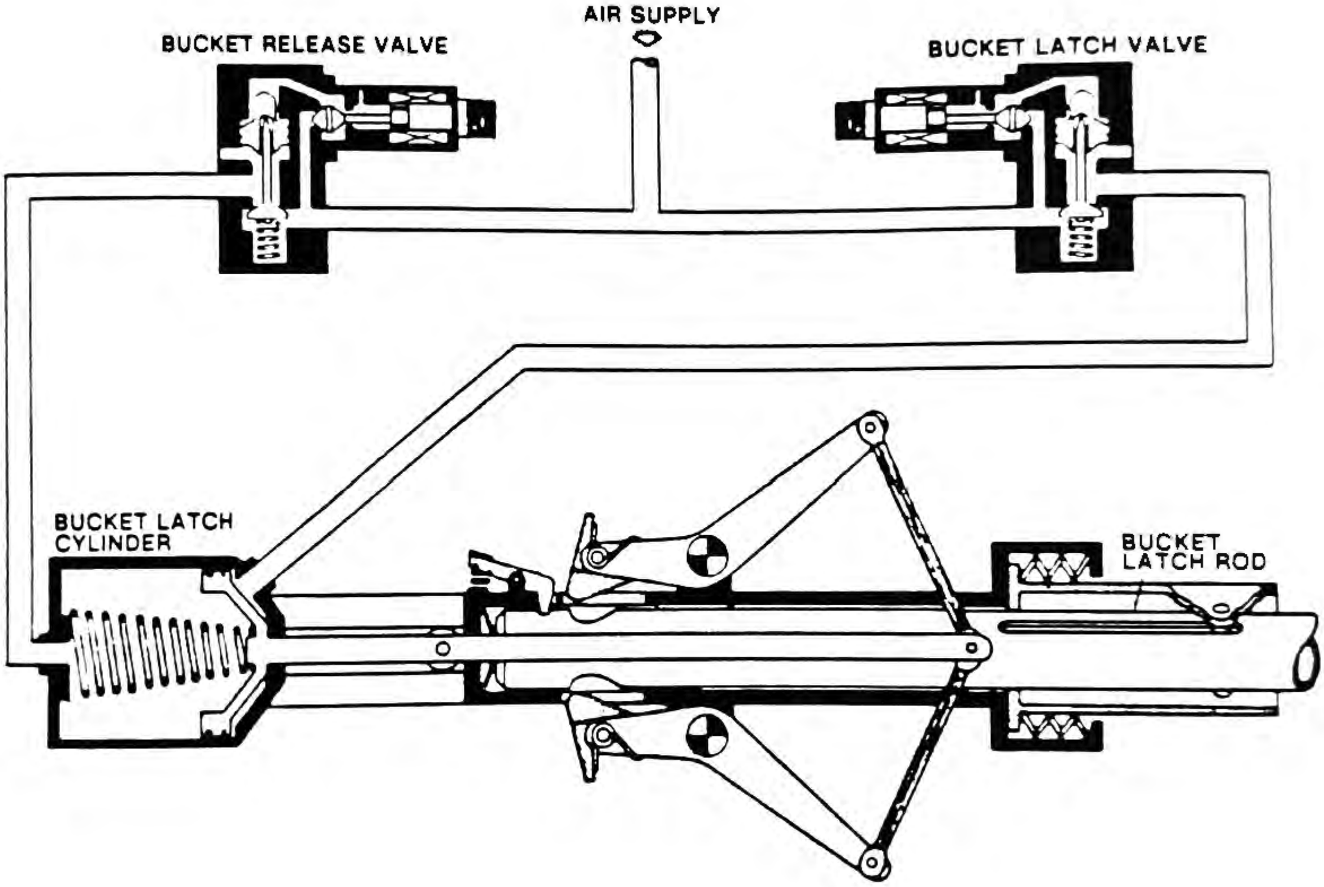
Figure 71-53



DEFLECTOR DOORS ACTUATING MECHANISM DEPLOYED FTX80595
Figure 71-54


28 VDC-4
DEFLECTOR DOORS RELEASE SWITCH
NORMAL
EMERGENCY (DUMP)
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
DEFLECTOR DOORS LATCH VALVE
ENGINE 4 PYLON
NOT DOWN
DOWN
RIGHT LANDING GEAR DOWN LIMIT SWITCH
RIGHT WHEELWELL
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
DEFLECTOR DOORS LATCH VALVE
ENGINE 3
FORWARD IDLE
FORWARD
THROTTLE THRUST REVERSER ARM NO CONTROL SWITCH (INBOARD ENGINES ONLY)
FORWARD THRUST
FORWARD IDLE
ENGINE 2
ENGINE 3 PYLON
NOT DOWN
DOWN
LEFT LANDING GEAR DOWN LIMIT SWITCH
LEFT WHEELWELL
DEFLECTOR DOORS LATCH VALVE
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
ENGINE 2 PYLON
DEFLECTOR DOORS LATCH VALVE
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
ENGINE 1 PYLON
28 VDC-1

DEFLECTOR DOORS LATCH VALVE, EMERGENCY RELEASE VALVE, AND ARMING CONTROL -- SCHEMATIC FTX80602
Figure 71-61



THRUST REVERSER BUCKET LATCH - SCHEMATIC

FTX80899

Figure 71-56

(3) The deflector doors release/latch assembly (see Figure 71-57) is mounted on the bottom of the pylon immediately aft of the engine rear mount. The release/latch assembly incorporates a housing assembly, guide, and sleeve which holds the forward end of the release/latch rod. A bolt installed in the sleeve through a slot in the rod, permits the rod to move fore and aft in the guide. This prevents the rod from rotating or from leaving the guide. Two levers, one on each side of the housing, support spring-loaded latch pawls which are positioned at openings in the housing and intercept recesses in the side of the rod. The levers are connected by links to a support assembly and rod, which is attached to a piston within a pneumatically operated cylinder, located below the housing. The piston is spring-loaded to the rear, holding the latch pawls in the unlatched position. A spring-loaded detent on the upper surface of the housing engages a depression on top of the rod. The detent prevents excessive and unnecessary movement of the release/latch rod when the latch pawls are disengaged.

(4) The translating ring stow latch (see Figure 71-57) is mounted on the bottom of the pylon above and to the left of the deflector doors release/latch assembly. The stow latch consists of a mount bolted to the pylon structure, link, lever, pin, plate, cover, pawl assembly, latch, three springs and attaching parts. The latch engages the stop on the translating ring when the translating ring is in the stowed position. With the latch so engaged, the link and lever are held slightly over-center by the springs, locking the latch.

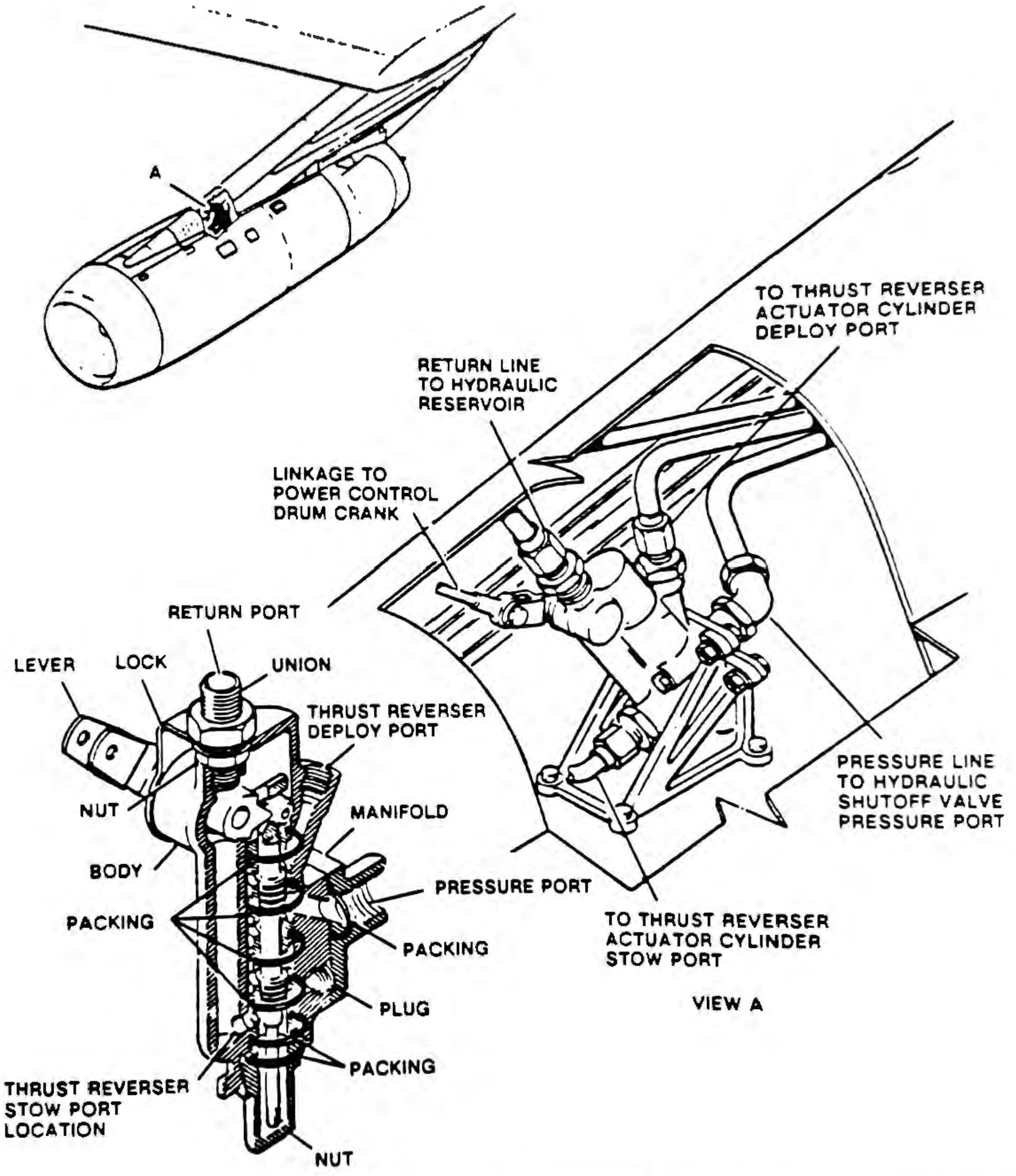
(5) The stow latch actuator cylinder is located inside the translating ring stow latch mount. The cylinder has two ports contained in a single boss and consists of the body, gland, piston, nut, lockring, scraper and backup rings, and packings. The piston assembly consists of a hollow piston head and rod sealed with a packing and backup rings. The end of the rod is rounded to engage the translating ring stow latch pawl assembly. The piston rod passes through and is sealed by the gland assembly. A piston rod scraper is installed in the end of the gland with a lockring. The gland is installed in the cylinder body and secured by an internal gland nut.

(6) The thrust reverser control valve (see Figure 71-58) directs hydraulic fluid pressure to the thrust reverser actuator cylinder and stow latch actuator cylinder. The control valve is mounted in the pylon box above the engine forward mounts. The control valve has four ports and contains a ported lapped assembly consisting of a slide and sleeve. Slide movement is controlled by a rod connected between a crank on the power control drum and a lever on one end of the slide. The position of the slide determines the direction of the hydraulic pressure through connecting lines to either the deploy, or stow ports, of the thrust reverser actuator cylinder and stow latch actuator cylinder to extend or retract the cylinder positions.

(7) The hydraulic shutoff valve (see figures 71-59 & 71-60) is a motor actuated rotary selector valve that controls the fluid flow from the main hydraulic system to the thrust reverser control valve. The shutoff valve has two ports, is solenoid operated, and is mounted on the forward inboard side of the left main gear wheel well. The shutoff valve is supplied with 28 VDC from DC bus 4 and controlled through the thrust reverser hydraulic control relay.

(8) The deflector doors latch valve and emergency release valve (see figures 71-61 & 71-63) are three-way, two-position, solenoid pilot-operated valves which control the supply of air from either the pneumatic manifold or engine 16th stage bleed. Each valve consists of a body, solenoid assembly, shaft, piston, two caps, piston ring, screen and retainer and a spring. The body of the valve has an inlet port, cylinder port, and vent port. The latch valves and emergency release valves used in the thrust reverser system, are mounted in the pylon box above the engine forward mounts. Each valve is supplied with 28 VDC from DC buses 1 and 4 and controlled through switches.

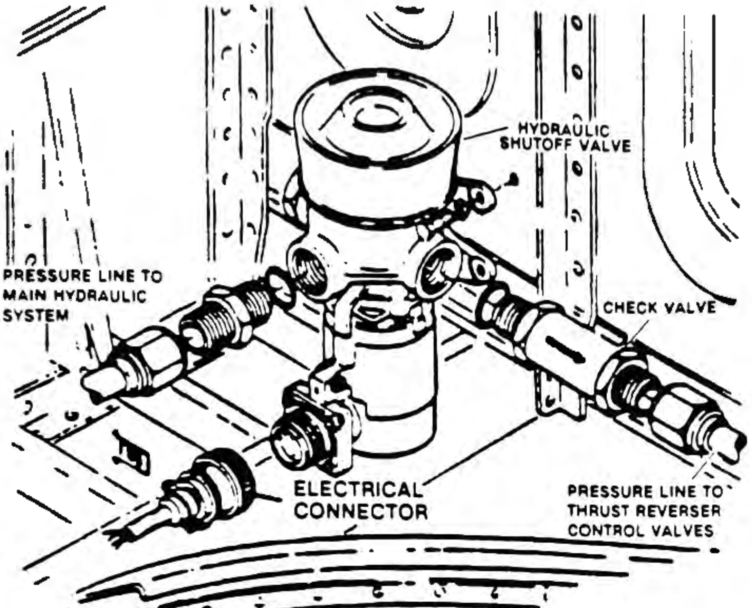
(9) The double check valve (see Figure 71-62) prevents the interflow of air between the high pressure and low pressure air supply systems, while providing for the usage of either engine 16th stage bleed air, or air from the aircraft pneumatic manifold for operation of the deflector doors release/latch assembly and interlock actuator cylinder. The check valve is mounted in the pylon box below the deflector doors latch valve, and deflector doors emergency release valve.


A
TO THRUST REVERSER ACTUATOR CYLINDER DEPLOY PORT
RETURN LINE TO HYDRAULIC RESERVOIR
LINKAGE TO POWER CONTROL DRUM CRANK
RETURN PORT
LEVER
LOCK
UNION
THRUST REVERSER DEPLOY PORT
NUT
MANIFOLD
BODY
PRESSURE PORT
PACKING
PACKING
PLUG
PACKING
THRUST REVERSER STOW PORT LOCATION
NUT
PRESSURE LINE TO HYDRAULIC SHUTOFF VALVE PRESSURE PORT
TO THRUST REVERSER ACTUATOR CYLINDER STOW PORT
VIEW A

THRUST REVERSER CONTROL VALVE

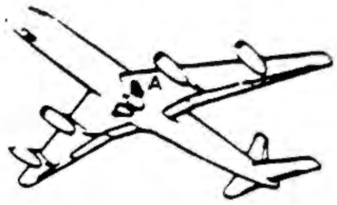
FTX80599

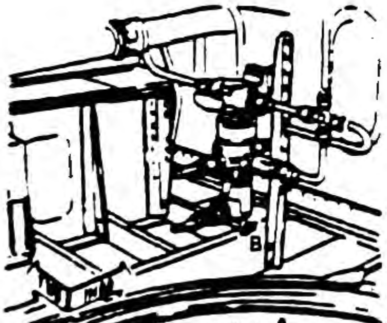
Figure 71-58


HYDRAULIC SHUTOFF VALVE
PRESSURE LINE TO MAIN HYDRAULIC SYSTEM
CHECK VALVE
ELECTRICAL CONNECTOR
PRESSURE LINE TO THRUST REVERSER CONTROL VALVES

VIEW B

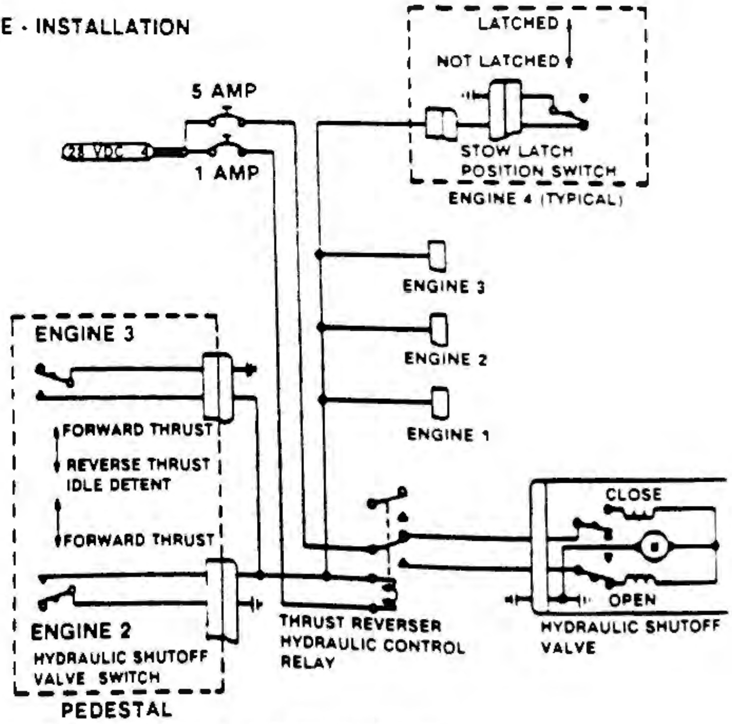
HYDRAULIC SHUTOFF VALVE - INSTALLATION





VIEW A

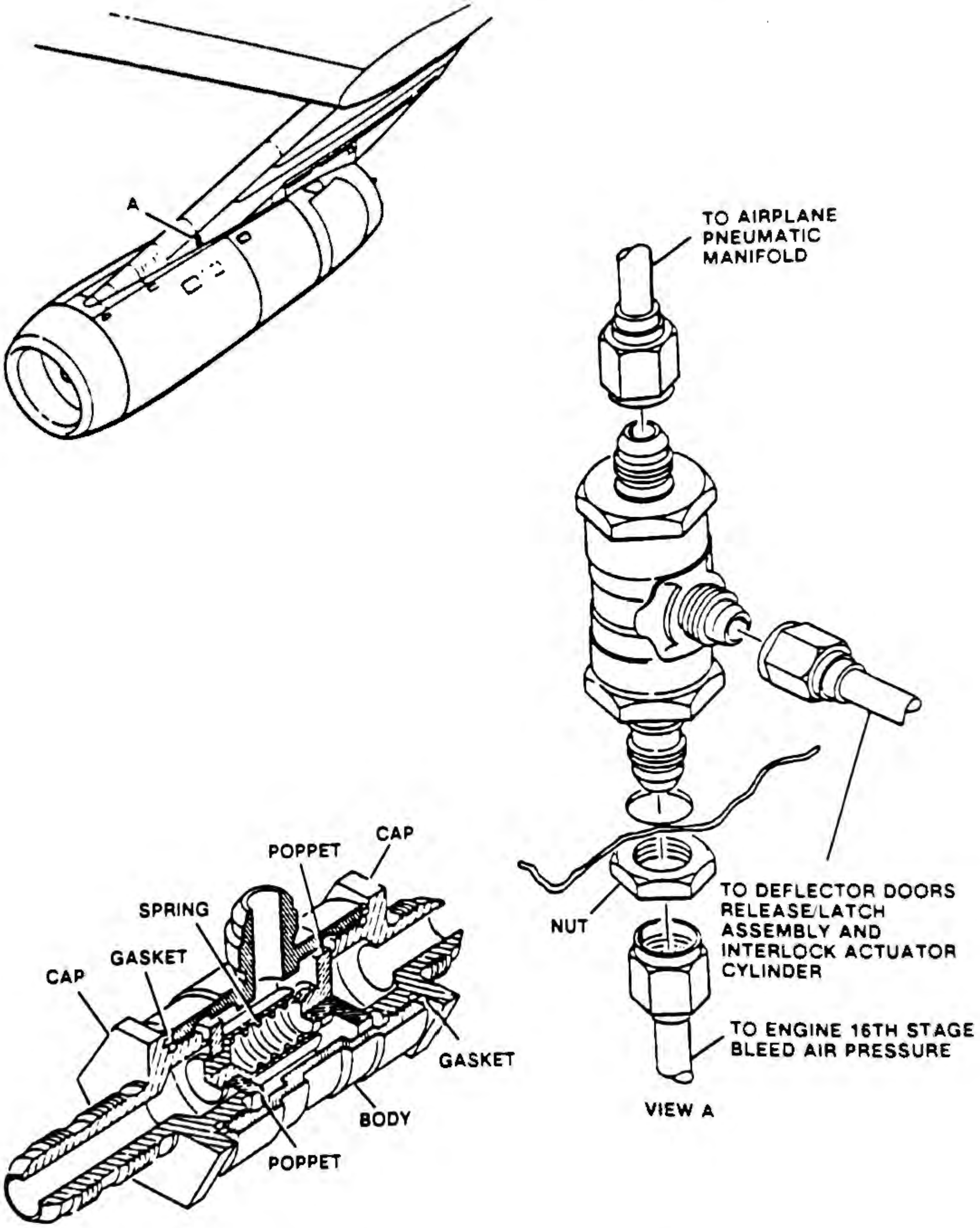
LEFT MAIN GEAR WHEEL WELL



THRUST REVERSER HYDRAULIC SHUTOFF VALVE CONTROL - SCHEMATIC

FTX80611

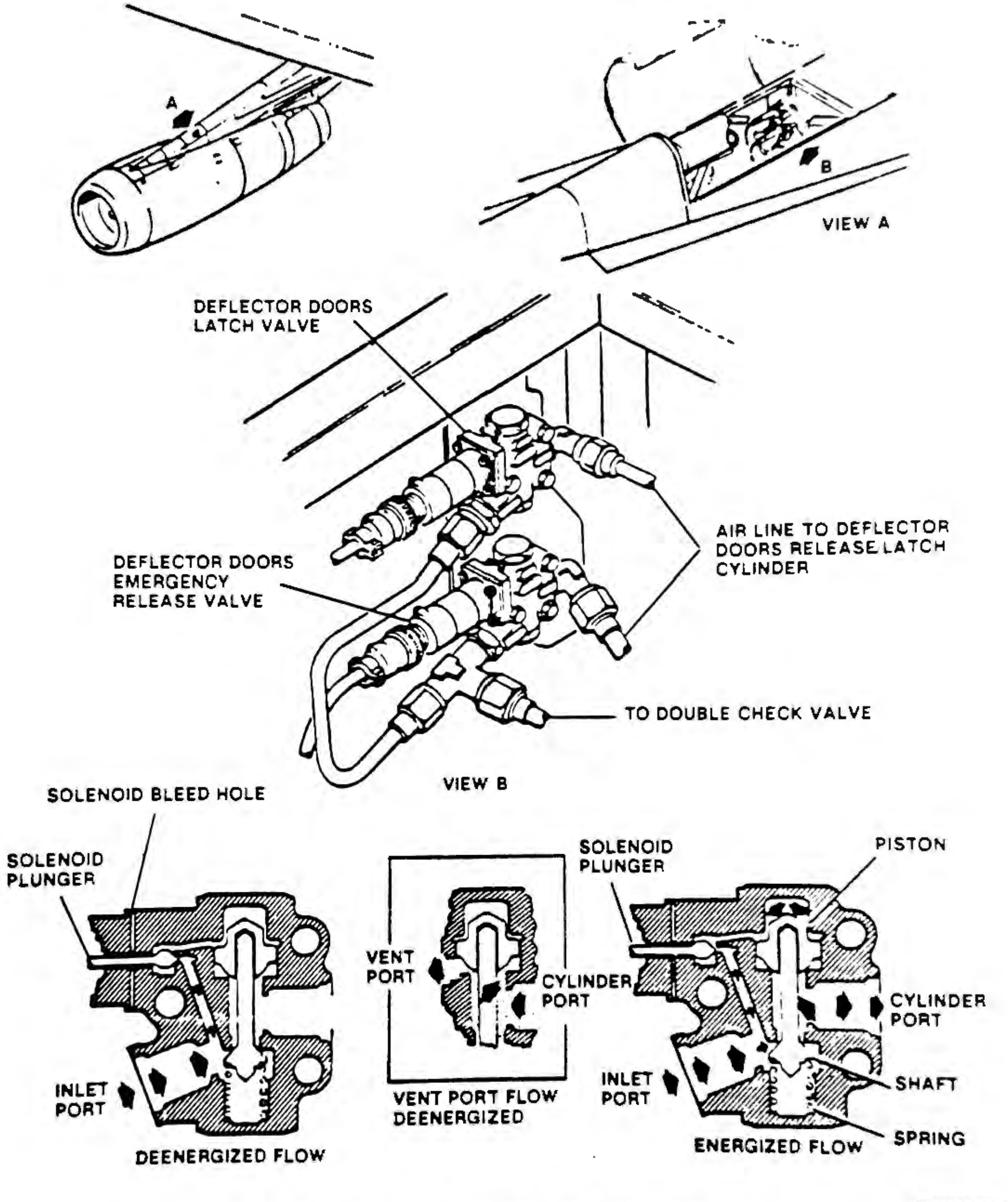
Figure 71-60


A
TO AIRPLANE PNEUMATIC MANIFOLD
TO DEFLECTOR DOORS RELEASE/LATCH ASSEMBLY AND INTERLOCK ACTUATOR CYLINDER
NUT
TO ENGINE 16TH STAGE BLEED AIR PRESSURE
VIEW A
CAP
POPPET
SPRING
GASKET
CAP
GASKET
BODY
POPPET

DOUBLE CHECK VALVE

FTX80601

Figure 71-62



DEFLECTOR DOORS LATCH AND EMERGENCY RELEASE VALVE
Figure 71-63

Low pressure air supplied through the pneumatic manifold is used primarily for ground testing operations when the engines are not operating. High pressure 16th stage bleed air from the engines is used for operation during flight. The check valve consists of a body with two inlet ports and an outlet port, two poppets, two caps, and a spring. The poppets seat on the inlet ports, held closed in opposed positions by the spring.

(10) The thrust reverser interlock system includes the nose landing gear interlock system, landing gear control lever interlock system, and power control drum interlock system.

(11) The thrust reverser emergency control system provides for stowing the deflector doors in flight if the translating ring is in the aft position with the doors deployed and an emergency occurs.

(12) The thrust reverser indicating system includes the translating ring position switch, stow latch position switch, deflector doors position switch, and thrust reverser indicating light.

E. Operation

(1) With the aircraft on the ground and the landing gear down and locked, reverse thrust on the inboard engines is initiated as follows:

(a) When the thrust reverser electrically operated standby hydraulic system pump is switched on, a blue indicating light mounted on a panel in the flight compartment comes on. The light indicates that the pump is running and providing a constant standby hydraulic pressure in event of failure of the main hydraulic system.

(b) Placing an inboard engine throttle/thrust reverser lever in the reverse thrust detent position, closes a hydraulic shutoff valve switch and 28 VDC is supplied to open the hydraulic shutoff valve connecting the thrust reverser hydraulic system to the aircraft main hydraulic system. At the same time, through mechanical linkage with the throttle/thrust reverser lever and power control drum, the thrust reverser control valve is positioned to supply hydraulic pressure to the thrust reverser actuator cylinder and stow latch actuator cylinder. The stow latch actuator cylinder releases the over-center stow latch lever and link permitting the translating ring to extend under the action of the thrust reverser actuator cylinder. Release of the over-center stow latch lever and link causes the stow latch position switch to close, supplying 28 VDC to the hydraulic shutoff valve, and via a flasher, to an amber indicating light. The indicating light continues flashing while the translating ring is extending.

(c) As the translating ring begins to extend, the translating ring position switch closes. This switch acts as a backup to the stow latch position switch amber indicating light circuit. Should the stow latch move to the latched position while the translating ring is deployed or before the translating ring is stowed, the amber light would continue flashing. The stow latch position switch supplies 28 VDC to the hydraulic shutoff valve in addition to that supplied through the hydraulic shutoff valve switch.

(d) When the deflector doors latch valve is energized, high or low pressure air from the engine 16th stage bleed or pneumatic manifold is permitted to reach the deflector doors release/latch cylinder, causing the pawls to engage the release/latch rod. As the translating ring nears the end of its extension, the stop on the aft end of the release/latch rod engages the deflector doors upper mechanism, resulting in rotation and deployment of the deflector doors. When fully deployed, the deflector doors actuate a deflector doors position switch and the flashing amber indicating light becomes steady. The deflector doors also actuate the thrust reverser interlock linkage which in turn operates the interlock valve via a cable link. The interlock valve permits air pressure to be applied to the interlock actuator cylinder moving the crank free of the stop on the power control drum. The throttle/thrust reverser lever is then free to move from the reverse thrust detent, to the full reverse thrust position, provided, the landing gear control lever is in the down position, moving the thrust reverser gate drum stop clear of the thrust reverser gate drum roller.

(2) With the aircraft on the ground and the landing gear down and locked, reverse thrust operation for the outboard engines is similar to that for the inboard engines except, there is no hydraulic shutoff valve switch to open the hydraulic shutoff valve.

(a) With the electrical buses energized, the thrust reverser electrically operated standby hydraulic system pump is switched on and a blue indicating light mounted on a panel in the flight compartment comes on. When an outboard engine throttle/thrust reverser lever is placed in the reverse thrust detent position, the thrust reverser control valve is positioned to supply hydraulic pressure to extend the thrust reverser actuator cylinder and stow latch actuator cylinder. The stow latch actuator cylinder releases the stow latch lever and link from the overcenter position permitting the translating ring to extend under the action of the thrust reverser actuator cylinder.

(b) As the translating ring begins to extend, the stow latch position switch closes and 28 VDC is supplied through the switch to open the hydraulic shutoff valve. Opening the valve, allows hydraulic pressure from the main hydraulic system to supplement the standby hydraulic pump pressure. If the inboard engines are not running, the main hydraulic system auxiliary hydraulic pump is off, and no external hydraulic source is connected, extension of the translating ring will continue under pressure supplied by the thrust reverser standby hydraulic system.

(c) Electrical power to energize the thrust deflector doors latch valve is supplied through the landing gear down limit switch. All other thrust reverser operations continue similar to the inboard engines.

(3) Stowing of the translating ring is accomplished as follows:

(a) When the inboard engines throttle/thrust reverser lever is placed in the forward idle position, the hydraulic shutoff valve switch is opened. At the same time, through mechanical linkage with the throttle/thrust reverser lever and power control drum, the thrust reverser control valve is positioned to supply hydraulic pressure to the stow side of the thrust reverser actuator cylinder and stow latch actuator cylinder. The alternate source of electrical power provided for the hydraulic shutoff valve through the closed stow latch position switch, ensures that the hydraulic power source remains uninterrupted. As the translating ring moves forward, pressure on the deflector doors upper mechanism caused by the deflector doors release/latch rod, is removed, and the doors rotate to the stowed position. Hydraulic pressure applied to the stow latch actuator cylinder, results in withdrawal of the piston rod permitting the stow latch mechanism to actuate closed when the thrust reverser returns to the stowed position. The latching action of the stow latch opens the stow latch position switch, deenergizing the hydraulic shutoff valve.

(b) Stowing operations for the outboard engines is similar to the inboard engines except that there are no hydraulic shutoff valve switches.

(4) Operation During Flight With the Landing Gear Up

(a) With the aircraft in flight and landing gear up, reverse thrust stop power is possible with the inboard engines only. When an inboard engine throttle/thrust reverser lever is placed in the forward idle position, a throttle/thrust reverser arming control switch is actuated closed by the throttle lever. This switch is in parallel with the main landing gear down limit switches and permits deployment of the inboard engine thrust deflector doors when the landing gear is up. Closing of the throttle/thrust reverser arming control switch, energizes the solenoid operated deflector doors latch valve which opens, permitting engine 16th stage bleed or pneumatic manifold air pressure to reach the deflector doors release/latch assembly cylinder. The deflector doors release/latch assembly pawls are then positively engaged with the release/latch rod causing the stop at the end of the rod to bear against the upper actuating mechanism of the deflector doors. This action rotates and deploys the deflector doors as the translating ring moves to the full aft position. When the throttle/thrust reverser lever is moved from reverse thrust to the forward idle position, the deflector doors and translating ring return to the stowed position as in ground operation.

(b) With the landing gear control lever in the up position, the throttle/thrust reverser levers for the outboard engines cannot be rotated into the reverse thrust detent position, thus preventing deployment of the translating rings on the outboard engines. The restraint on the outboard engine throttle/thrust the translating rings on the outboard engines. The restraint on the outboard engine throttle/thrust reverser levers is effected by the landing gear control lever being in the up position, placing the thrust reverser gate stop upper step in the full aft position to engage the thrust reverser gate drum roller.

D. Mechanical Linkage (See Figure 71-65)

The mechanical linkage includes a clevis, two arms, link, and shaft located in the thrust reverser translating ring, and two shafts, four arms, two supports, two springs, cable assembly, two rod ends, link, clamps, spacer, retainer, switch, and a cover, located in the engine pylon.

E. Interlock Valve (See Figure 71-65)

The interlock valve consists of a valve body containing a poppet, link and needle assembly, two springs, plug, and arm. The needle assembly is spring-loaded and held in place by a pivoting lever at one end of the body. The lever has two positions and is actuated by the mechanical linkage. A plug seals the opposite end of the valve body. Two ports, an inlet and outlet, are provided on the valve body. The inlet port is connected to a line from the engine 16th stage bleed air and the aircraft pneumatic manifold. The outlet port is connected to the interlock actuator cylinder.

F. Interlock Actuator Cylinder

The interlock actuator cylinder consists of a head, piston, cylinder, cover, end, shaft, clevis, pawl assembly, and two springs. The actuator cylinder rod end is attached to a crank which is centered on the power control drum shaft. The actuator cylinder has a single port to which the interlock valve line is connected.

G. Operation

(1) With the landing gear control lever in the up position, the stops welded to the thrust reverser gate stop assembly tube are held in line with the gate drum rollers allowing reverse thrust to the reverse power stop position, which is slightly aft of the reverse thrust detent position on the inboard engines only. The throttle/thrust reverser levers for the outboard engines cannot be rotated into the reverse thrust detent position. The restraint on the outboard engines throttle/thrust reverser levers is effected by the landing gear control lever being in the up position, allowing the outboard engines thrust reverser gate stop upper step to engage the thrust reverser gate drum roller.

(5) Operation During Flight With Landing Gear Down

(a) During flight with landing gear down, reverse thrust is possible on all four engines. The inboard and outboard engines have full reverse thrust capability. Reverse thrust is initiated by turning the electrically operated standby hydraulic pump on, and placing the throttle/thrust reverser lever in the reverse thrust position. The translating ring and deflector doors will deploy as in ground operation.

(b) With the landing gear control lever in the down position, the thrust reverser gate stop is clear of the thrust reverser gate drum roller, permitting the throttle/thrust reverser levers to be placed in the full reverse thrust position.

(6) Emergency Operation

Should an emergency develop while the thrust deflector doors are deployed, the deflector doors emergency release switch is placed in the emergency release (dump) position. The deflector doors emergency release valve is energized, and the valve opens permitting air pressure from the engine 16th stage bleed or pneumatic manifold, to reach the deflector doors release/latch assembly cylinder. The air pressure forces the piston aft releasing the pawls and disengaging the release/latch rod, permitting the deflector doors upper mechanism at the translating ring to release the rod from the the latched position. With the pawls released, the deflector doors are immediately rotated to the stowed position by pressure from the engine exhaust gases and action of the deflector doors upper and lower spring-loaded mechanism.

29. Thrust Reverser Interlock System - Description and Operation

A. General

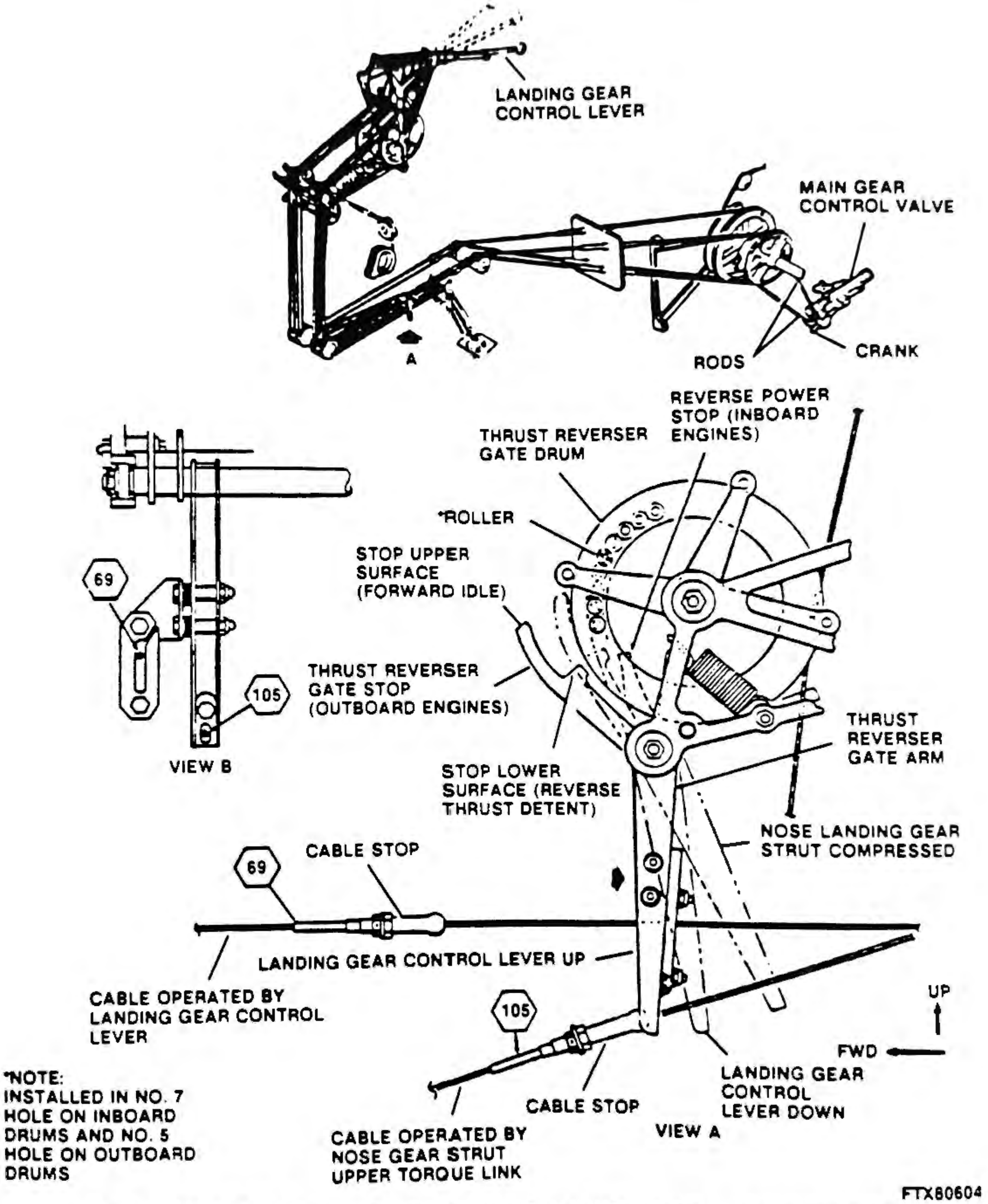
The thrust reverser interlock system includes the landing gear control lever interlock and power control drum interlock.

B. Landing Gear Control Lever Interlock (See Figure 71-64)

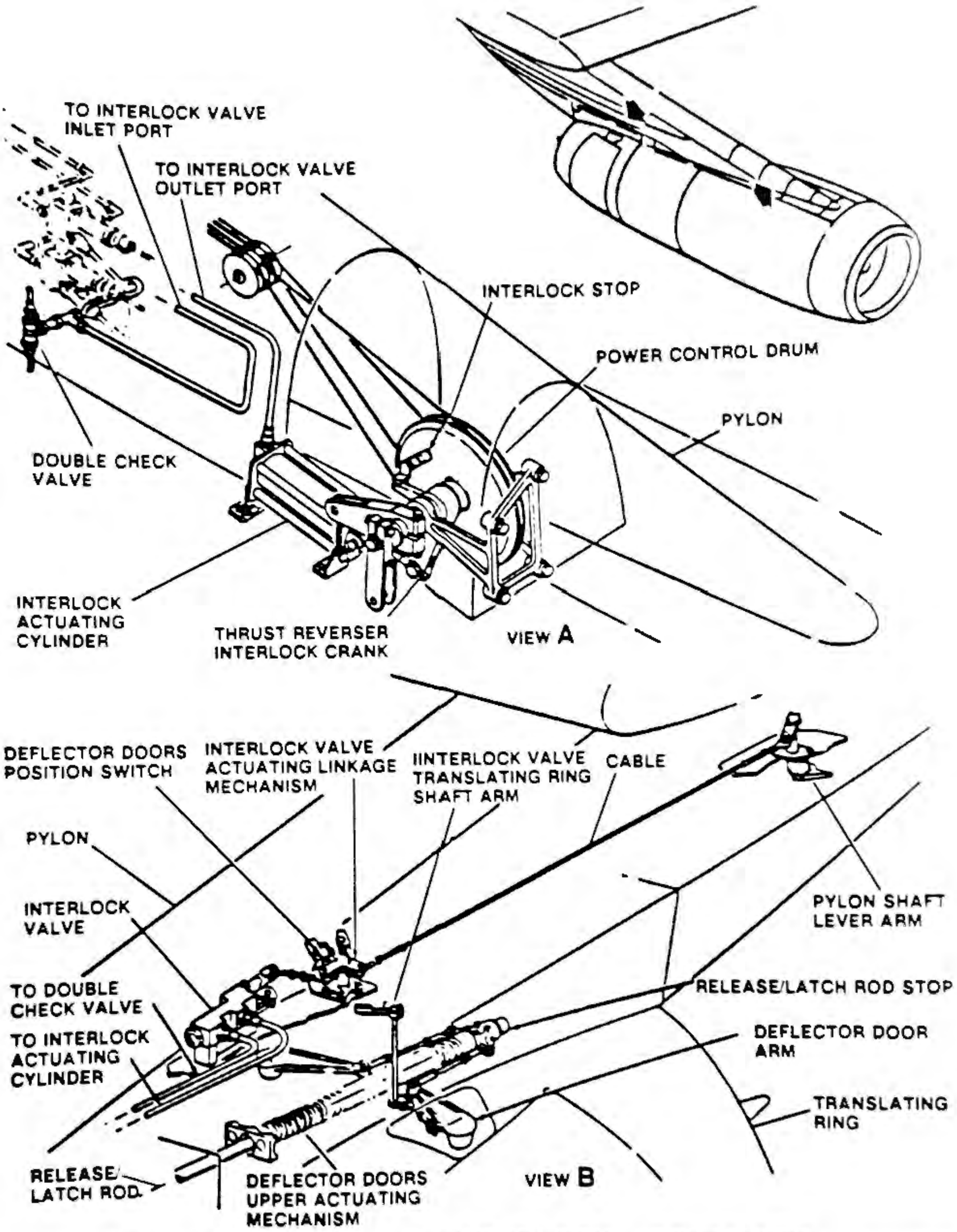
The landing gear control lever interlock prevents the selection of reverse thrust on the outboard engines. When the landing gear control lever is in the down position, full reverse thrust power is obtainable on the inboard engines and outboard engines. The interlock consists of a stop mounted on a cable link between the landing gear control lever and the main gear control valve. The cable passes through the thrust reverse gate arm guide located below and forward of the control pedestal.

C. Power Control Drum Interlock (See Figure 71-65)

The power control drum interlock is a mechanical linkage actuated by deflector door movement which operates an interlock valve which in turn supplies air pressure to an interlock actuator. The interlock prevents selection of the full reverse thrust power range until the deflector doors have been deployed. The interlock consists of a mechanical linkage, valve actuator cylinder, crank, and power control drum stop.

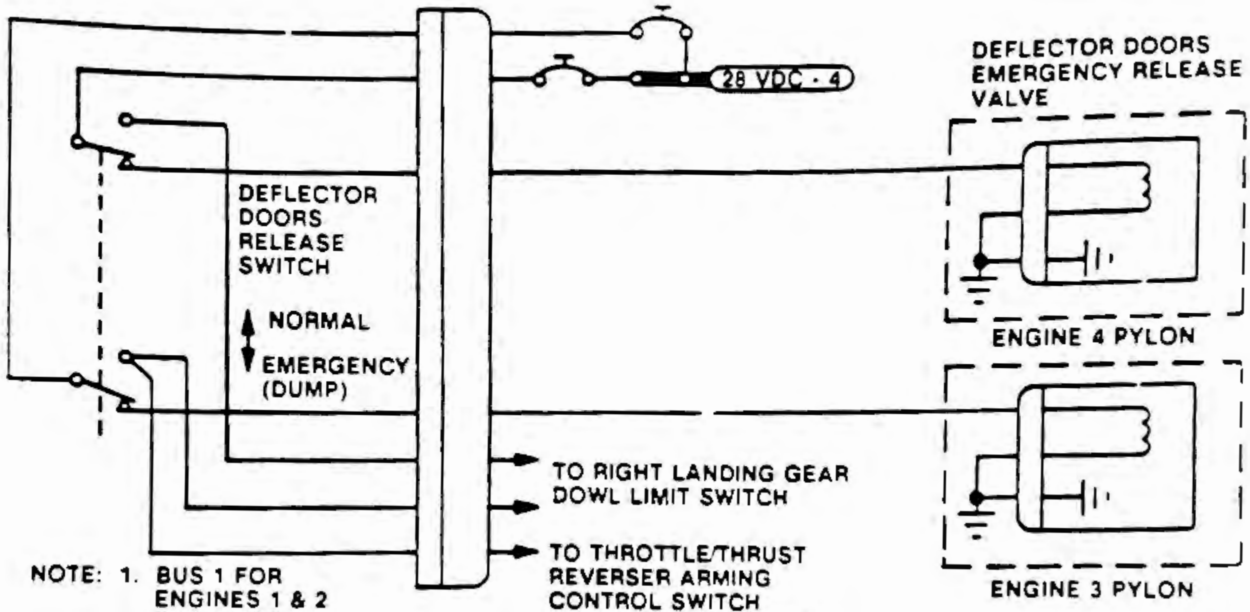

LANDING GEAR CONTROL LEVER
MAIN GEAR CONTROL VALVE
A
RODS
CRANK
REVERSE POWER STOP (INBOARD ENGINES)
THRUST REVERSER GATE DRUM
*ROLLER
STOP UPPER SURFACE (FORWARD IDLE)
69
105
THRUST REVERSER GATE STOP (OUTBOARD ENGINES)
VIEW B
STOP LOWER SURFACE (REVERSE THRUST DETENT)
THRUST REVERSER GATE ARM
NOSE LANDING GEAR STRUT COMPRESSED
69
CABLE STOP
LANDING GEAR CONTROL LEVER UP
CABLE OPERATED BY LANDING GEAR CONTROL LEVER
105
UP
FWD
LANDING GEAR CONTROL LEVER DOWN
CABLE STOP
VIEW A
CABLE OPERATED BY NOSE GEAR STRUT UPPER TORQUE LINK
*NOTE:
INSTALLED IN NO. 7 HOLE ON INBOARD DRUMS AND NO. 5 HOLE ON OUTBOARD DRUMS
FTX80604

LANDING GEAR CONTROL LEVER INTERLOCK -- SCHEMATIC
Figure 71-64


TO INTERLOCK VALVE INLET PORT
TO INTERLOCK VALVE OUTLET PORT
INTERLOCK STOP
POWER CONTROL DRUM
PYLON
DOUBLE CHECK VALVE
INTERLOCK ACTUATING CYLINDER
THRUST REVERSER INTERLOCK CRANK
VIEW A
DEFLECTOR DOORS POSITION SWITCH
INTERLOCK VALVE ACTUATING LINKAGE MECHANISM
IINTERLOCK VALVE TRANSLATING RING SHAFT ARM
CABLE
PYLON
INTERLOCK VALVE
TO DOUBLE CHECK VALVE
TO INTERLOCK ACTUATING CYLINDER
PYLON SHAFT LEVER ARM
RELEASE/LATCH ROD STOP
DEFLECTOR DOOR ARM
TRANSLATING RING
RELEASE/LATCH ROD
DEFLECTOR DOORS UPPER ACTUATING MECHANISM
VIEW B

POWER CONTROL DRUM INTERLOCK -- SCHEMATIC FFTX80606

Figure 71-65


28 VDC - 4
DEFLECTOR DOORS EMERGENCY RELEASE VALVE
DEFLECTOR DOORS RELEASE SWITCH
NORMAL
EMERGENCY (DUMP)
ENGINE 4 PYLON
ENGINE 3 PYLON
TO RIGHT LANDING GEAR DOWL LIMIT SWITCH
TO THROTTLE/THRUST REVERSER ARMING CONTROL SWITCH (INBOARD ENGINE ONLY)

NOTE: 1. BUS 1 FOR ENGINES 1 & 2
BUS 4 FOR ENGINES 3 & 4

2. ENGINES 3 & 4 SHOWN. ENGINES 1 & 2 SIMILAR

THRUST REVERSER EMERGENCY CONTROL SYSTEM -- SCHEMATIC

FTX80609

Figure 71-68

(2) Landing Gear Control Lever in Down Position

With the landing gear control lever in the down position, reverse thrust is possible on all four engines. The inboard and outboard engines have full reverse thrust capability. With the landing gear control lever in the down position, the thrust reverser gate stop is clear of the thrust reverser gate drum roller, permitting the inboard and outboard engines throttle/thrust reverser levers to be placed in the full reverse thrust position.

(3) Power Control Drum Interlock

(a) During normal engine operation with the translating ring in the forward thrust position and the deflector doors stowed, air pressure is present in the line to the interlock valve. However, the interlock valve inlet is blocked by the poppet and the vent port is open, causing the interlock actuator cylinder rod to retract, preventing movement of the power control drum to the full reverse thrust power range. When the throttle/thrust reverser lever is moved to the reverse thrust idle detent position, the translating ring moves aft and the deflector doors deploy. As the doors reach the fully deployed position, the left deflector door upper arm actuates a mechanical linkage causing the interlock valve to supply air pressure to the interlock actuator cylinder. The pressurized air enters the cylinder and forces the piston and shaft outward, rotating the crank at the power control drum. The power control drum and stop are then free to rotate to the full reverse thrust power range. Air pressure remains in the interlock actuator cylinder as long as the deflector doors remain fully deployed.

(b) When the throttle/thrust reverser lever is placed in the forward idle position, the deflector doors leave the fully deployed position, causing the spring-loaded mechanical linkage to actuate the interlock valve closed. This seats the poppet closing the interlock valve inlet port and positions the needle assembly to open the vent port, venting air pressure from the interlock actuator cylinder and lines. When the air pressure is exhausted from the actuator cylinder, spring pressure causes the cylinder shaft to retract and position the stop on the power control drum, so the drum cannot be moved beyond idle reverse thrust power.

30. Thrust Reverser Indicating System - Description and Operation

A. General

The thrust reverser indicating system is provided to show when the stow latch is unlatched, the translating ring is in transition, and the deflector doors are deployed, via mechanically actuated switches mounted on the engine pylon structure, and an indicating light located in the flight compartment. The system is supplied with 28 VDC from DC bus 1 and 4; through a circuit breaker located on the main circuit breaker panel.

B. Translating Ring Position Switch (See Figure 71-66)

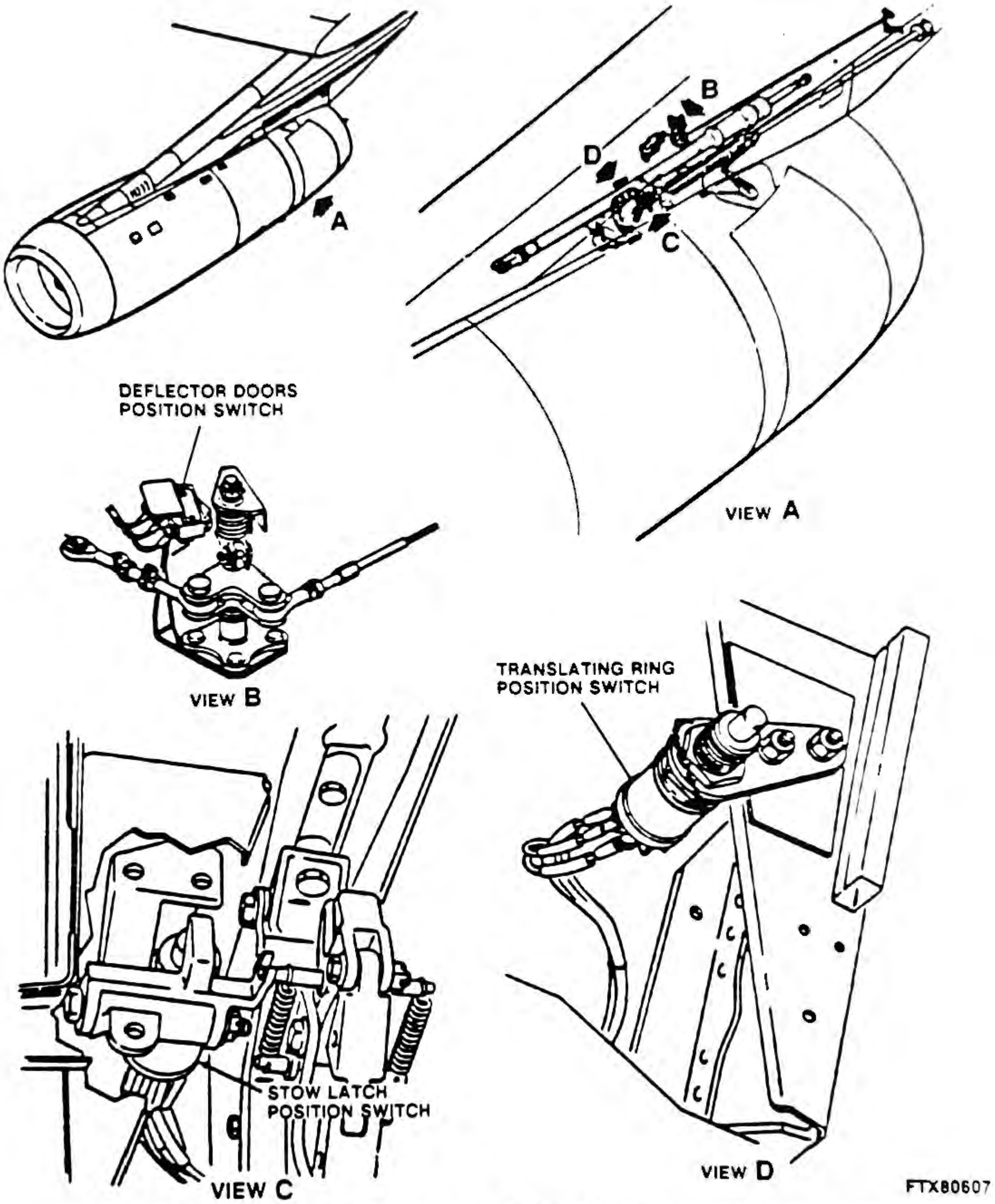
The translating ring position switch is mounted on a support attached to the pylon structure right side, adjacent to the deflector doors release/latch assembly. The switch is hermetically sealed and plunger actuated, with two single-pole, double toggle contacts.

C. Deflector Doors Position Switch (See Figure 71-66)

The deflector doors position switch is mounted on the interlock mechanism support inside the pylon, above the pylon firewall, aft of the engine rear mounts. The switch is hermetically sealed, single-pole, double toggle.

D. Stow Latch Position Switch (See Figure 71-66)

The stow latch position switch is mounted on a support attached to the pylon structure left side, adjacent to the stow latch. The switch is hermetically sealed and plunger actuated, with two single-pole, double toggle contacts.


A
B
D
C
VIEW A
DEFLECTOR DOORS POSITION SWITCH
VIEW B
TRANSLATING RING POSITION SWITCH
STOW LATCH POSITION SWITCH
VIEW C
VIEW D
FTX80607

THRUST REVERSER INDICATING SYSTEM POSITION SWITCHES
Figure 71-66

H. Cone Check Valve

A cone type check valve is installed in the standby hydraulic pump pressure line. The valve screws into the thrust reverser standby hydraulic system filter outlet and prevents reverse flow of fluid through the filter. The valve consists of the body, cone, spring, O-ring, and cap.

I. Vacuum Breaker Check Valve

The vacuum breaker check valve is located in the left wing root, near the aft face of the rear spar, secured to the hydraulic A-return line adjacent to the reservoir. The valve consists of an aluminum alloy body with two ports, poppet, spring, gasket, nipple, and cap. One port is connected to the reservoir, the other is open to ambient air.

J. Pressure Switch

The pressure switch is mounted on the aft face lower center of the rear spar. The switch is single-pole, double-toggle, and consists of a body, two springs, mount, actuating pin, lock ring, two register rings, pressure plate, snap ring, piston, seal, adjustment screw, and three O-rings. The body is provided with a pressure port and an electrical connector. The switch is supplied with 28 VDC from DC bus 1, through a circuit breaker located on the main circuit breaker panel.

K. Pressure Transmitter

The pressure transmitter is mounted on the outboard lower forward bulkhead section in the left main gear wheel well. The pressure transmitter senses hydraulic fluid pressure and displays this pressure on a gauge located in the flight compartment. The transmitter has provision for a hydraulic pressure port and an hermetically sealed electrical connector. The transmitter is supplied with 28 VAC from AC instrument bus 3, through a circuit breaker located on the main circuit breaker panel.

L. Hydraulic Pressure Indicator

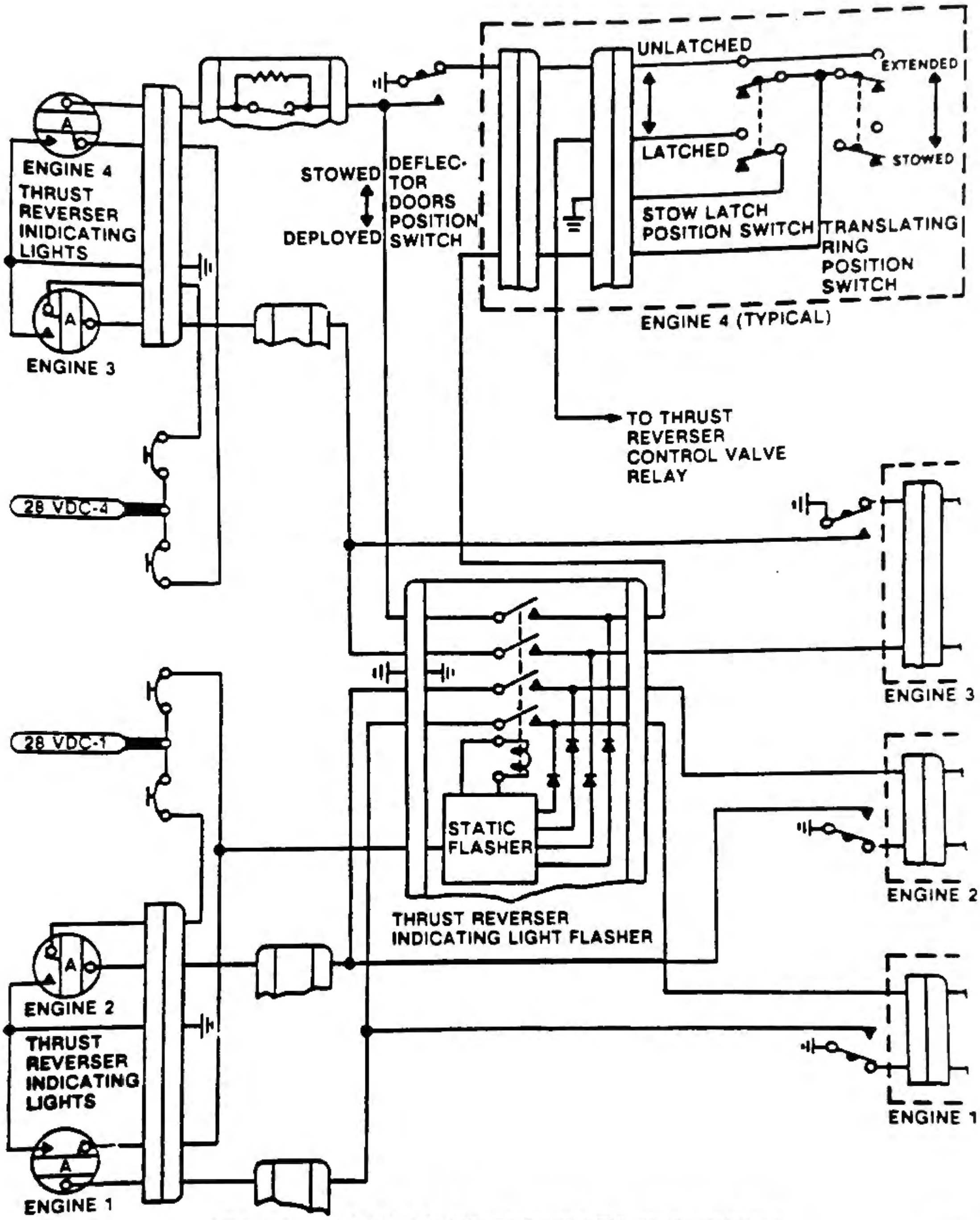
The thrust reverser hydraulic system pressure indicator is located in the flight compartment. The indicator serves a threefold purpose as follows:

(1) Indicates thrust reverser hydraulic system pressure when the standby hydraulic pump is on, and the hydraulic shutoff valve is closed.

E. Operation (See Figure 71-67)

(1) When the throttle/thrust reverser lever is placed in the reverse thrust idle detent position, hydraulic pressure is transmitted to the thrust reverser actuator cylinder and stow latch actuator cylinder. The stow latch actuator cylinder releases the overcenter stow latch permitting the translating ring to extend. Release of the overcenter stow latch causes the switch striker, actuated by latch movement, to close the stow latch position switch, supplying 28 VDC to the hydraulic shutoff valve and to the amber indicating light which comes on flashing. As the translating ring begins to extend, the translating ring position switch closes and acts as a backup to the stow latch position switch on the indicating light circuit. Should the stow latch shut before the translating ring is fully stowed, the indicating light would continue to flash. When the translating ring is fully extended and the deflector doors are deployed, the deflector doors position switch short circuits the indicating light flasher and the indicating light comes on steady.

(2) When the throttle/thrust reverser lever is moved to the forward idle position, hydraulic pressure is transmitted to the thrust reverser actuator cylinder and stow latch actuator cylinder. The stow latch actuator cylinder piston is withdrawn permitting the stow latch mechanism to actuate when the translating ring is in the stowed position. At the same time, the deflector doors position switch is actuated open when the deflector doors move to the stow position, causing the indicating light to go from steady to a flashing light. When the translating ring reaches the stowed position, the translating ring position switch opens. Simultaneously, the stow latch position switch opens deenergizing the hydraulic shutoff valve, and the indicating light goes out.


UNLATCHED
EXTENDED
LATCHED
STOWED
STOW LATCH POSITION SWITCH
TRANSLATING RING POSITION SWITCH
ENGINE 4 (TYPICAL)
STOWED
DEPLOYED
DEFLECTOR DOORS POSITION SWITCH
ENGINE 4 THRUST REVERSER INDICATING LIGHTS
A
ENGINE 3
TO THRUST REVERSER CONTROL VALVE RELAY
28 VDC-4
28 VDC-1
ENGINE 3
ENGINE 2
ENGINE 1
STATIC FLASHER
THRUST REVERSER INDICATING LIGHT FLASHER
ENGINE 2 THRUST REVERSER INDICATING LIGHTS
ENGINE 1

THRUST REVERSER INDICATING SYSTEM

FTX80608

Figure 71-67

31. Thrust Reverser Emergency Control System - Description and Operation

A. General

The thrust reverser emergency control system includes a deflector doors emergency release valve, and a two position deflector doors emergency release (dump) switch. The system is supplied with 28 VDC from DC bus 1 and 4 through a circuit breaker located on the main circuit breaker panel.

B. Deflector Doors Emergency Release (Dump) Valve

The valve is a three-way, two-position, solenoid pilot-operated valve which controls the supply of air from either the pneumatic manifold, or engine 16th stage bleed. The valve consists of a body, solenoid assembly, shaft, piston, two caps, piston ring, screen and retainers, and a spring. The body of the valve has an inlet port, cylinder port, and a vent port. The valve is mounted below the deflector doors latch valve, in the pylon box above the engine forward mounts.

C. Operation (See Figure 71-68)

Should an emergency develop while the thrust deflector doors are deployed, the deflector doors emergency release switch is placed in the dump position. The deflector doors emergency release valve is energized and the valve opens permitting air pressure from the pneumatic manifold or engine 16th stage bleed, to reach the deflector doors release/latch assembly cylinder. The air pressure forces the piston aft, releasing the pawls and disengaging the release/latch rod, permitting the deflector doors upper mechanism at the translating ring to release the rod from the latched position. With the pawls released, the deflector doors are immediately rotated to the stowed position by pressure from the engine exhaust gases and action of the deflector doors upper and lower spring-loaded mechanism.

32. Thrust Reverser Standby Hydraulic System - Description and Operation

A. General (See Figure 71-69)

The thrust reverser standby hydraulic system is used during all engine reverse thrust operations on the ground. The system includes an electric motor driven hydraulic pump, indicating light, two accumulators and restrictor valve, reservoir, manual shutoff valve, filter and relief valve, cone check valve, vacuum breaker check valve, pressure switch, pressure transmitter, hydraulic pressure indicator, and a control switch.

B. Standby Hydraulic Pump

The standby hydraulic pump is an electrically driven, pressure compensated, variable-displacement pump which acts as a backup to the main hydraulic system during operation of the thrust reverser system. The pump is mounted on the outboard forward shelf, aft of the rear spar, in the left main gear wheel well. The pump motor is driven by three phase, 115 vac, 400-cycle power from AC bus 3. Pump operation is controlled by a three-position, on, off, override, toggle switch located in the flight compartment. The pump has an inlet port, outlet port, seal cavity drain port, and a case drain port. A thermal cut-out switch installed in the pump motor prevents overheating of the motor.

C. Standby Hydraulic Pump Indicating Light

A blue indicating light located in the flight compartment indicates when the standby hydraulic pump is in operation. The indicating light is supplied with 28 VDC from DC bus 1, through a circuit breaker located on the main circuit breaker panel.

D. Hydraulic Accumulators and Restrictor Valve

(1) Two spherical, welded steel, 125-cubic inch capacity hydraulic accumulators are installed in the pressure line of the thrust reverser hydraulic system. The accumulators are mounted on the aft right side of the forward fuselage center section, in the right main gear wheel well. The accumulators provide a reserve supply of fluid under air pressure and act as a surge damper for the thrust reverser hydraulic system. Initial air charge of the accumulators is 1000 psig.

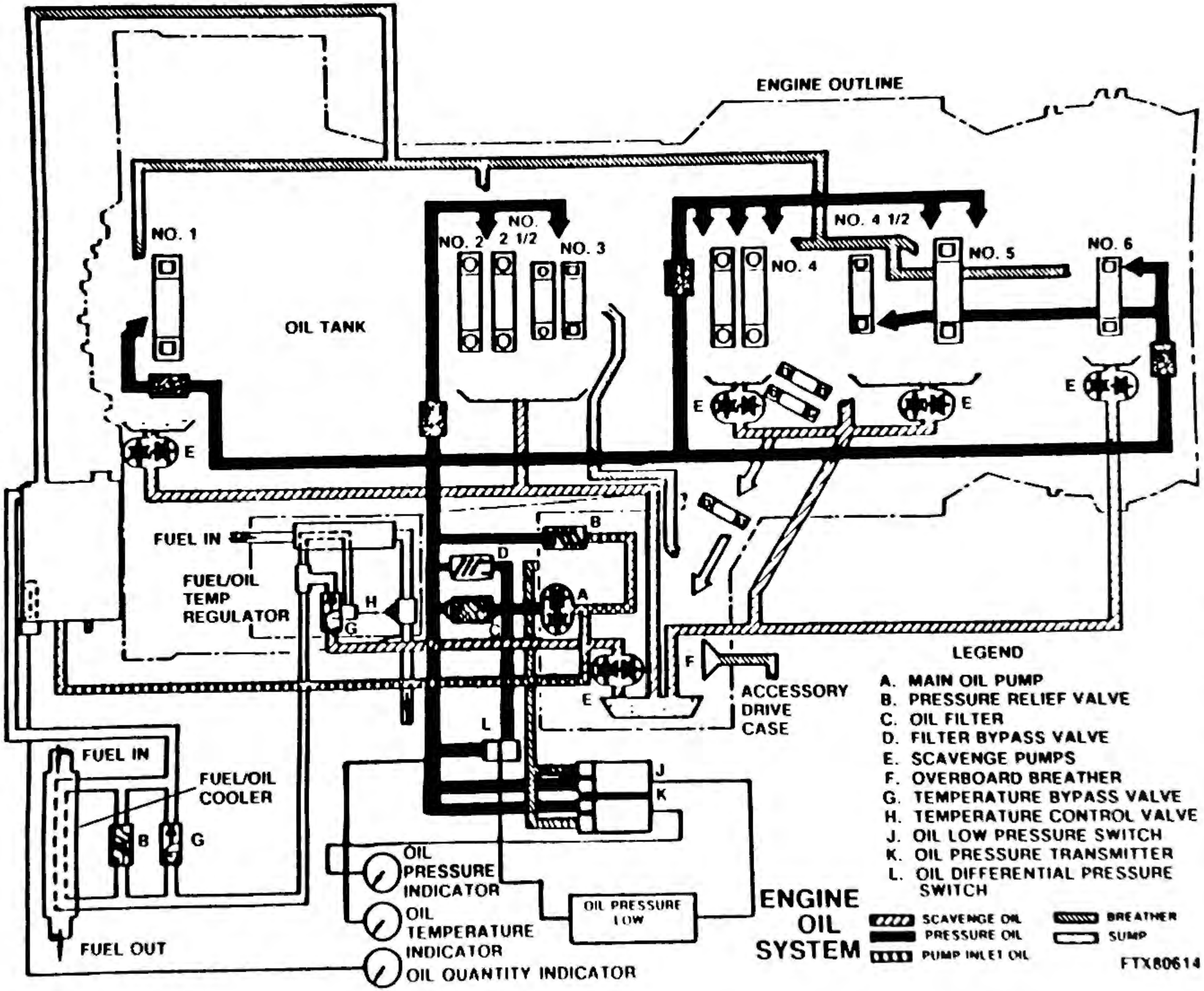
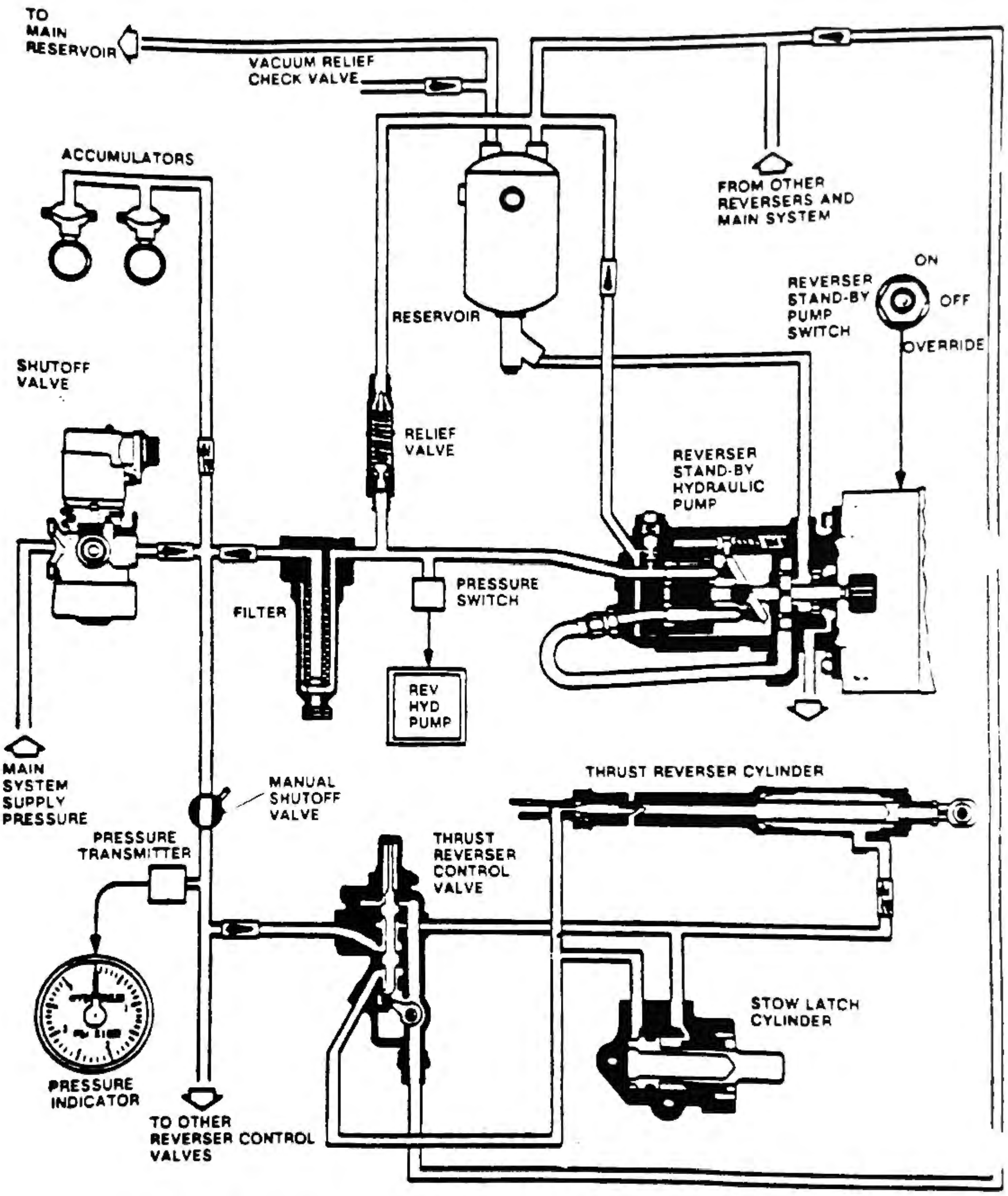

ENGINE OUTLINE
OIL TANK
NO. 1
NO. 2
NO. 2 1/2
NO. 3
NO. 4
NO. 4 1/2
NO. 5
NO. 6
E
FUEL IN
FUEL/OIL TEMP REGULATOR
H
G
D
B
A
C
F
L
J
K
ACCESSORY DRIVE CASE
FUEL IN
FUEL/OIL COOLER
B
G
FUEL OUT
OIL PRESSURE INDICATOR
OIL TEMPERATURE INDICATOR
OIL QUANTITY INDICATOR
OIL PRESSURE LOW
ENGINE OIL SYSTEM
LEGEND
A. MAIN OIL PUMP
B. PRESSURE RELIEF VALVE
C. OIL FILTER
D. FILTER BYPASS VALVE
E. SCAVENGE PUMPS
F. OVERBOARD BREATHER
G. TEMPERATURE BYPASS VALVE
H. TEMPERATURE CONTROL VALVE
J. OIL LOW PRESSURE SWITCH
K. OIL PRESSURE TRANSMITTER
L. OIL DIFFERENTIAL PRESSURE SWITCH
SCAVENGE OIL
PRESSURE OIL
PUMP INLET OIL
BREATHER
SUMP
FTX80614

Figure 71-72


TO MAIN RESERVOIR
VACUUM RELIEF CHECK VALVE
ACCUMULATORS
FROM OTHER REVERSERS AND MAIN SYSTEM
ON
REVERSER STAND-BY PUMP SWITCH
OFF
OVERRIDE
RESERVOIR
SHUTOFF VALVE
RELIEF VALVE
REVERSER STAND-BY HYDRAULIC PUMP
FILTER
PRESSURE SWITCH
REV HYD PUMP
MAIN SYSTEM SUPPLY PRESSURE
THRUST REVERSER CYLINDER
MANUAL SHUTOFF VALVE
PRESSURE TRANSMITTER
THRUST REVERSER CONTROL VALVE
STOW LATCH CYLINDER
PRESSURE INDICATOR
TO OTHER REVERSER CONTROL VALVES

THRUST REVERSER HYDRAULIC CONTROL SYSTEM SCHEMATIC FTX80610

Figure 71-69

(2) The restrictor valve is a one-way filtered valve which combines the functions of a restrictor and check valve. The valve is installed in the accumulators pressure line to provide a controlled rate in one direction, and Free flow in the opposite direction. The valve is located below the accumulators in the right main gear wheel well. The valve consists of a body, cap, poppet, spring, filter, mandrel, retainer, O-ring, and backup ring.

E. Reservoir

The thrust reverser standby hydraulic system reservoir is of cadmium-plated steel construction with two bosses on the top, one boss on the bottom, a sight gauge housing on the side. A magnetic drain plug is mounted on the bottom of the reservoir. The reservoir is mounted near the aft face of the rear spar in the forward inboard section of the left wing root area. Capacity of the reservoir is 2.38 US gallons.

F. Manual Shutoff Valve

A two-position rotary on, off, manually operated shutoff valve is installed in the pressure line to the thrust reverser control valves. The shutoff valve is used to prevent operation of the thrust reversers during maintenance practices on the thrust reverser system. The valve is mounted on the inboard left side of the forward fuselage center section, in the left main gear wheel well. Lockwire holes are provided in the handle of the valve to safety wire the valve in the open position.

G. Filter and Relief Valve

(1) The inline micronic filter is mounted on the aft face of the rear spar in the left main gear wheel well. The filter has an inlet port and an outlet port, and houses a stainless steel mesh element. A magnetic plug is installed in the sump of the filter body.

(2) The relief valve relieves excess fluid pressure buildup in the thrust reverser standby hydraulic system. The valve is installed in the pressure line between the standby hydraulic pump and the filter, and is mounted in the left main gear wheel well adjacent to the filter. The valve consists of an aluminum body with two ports, seat assembly, poppet, guide, spring, retainer, adjusting screw and nut, O-ring, and backup ring.

(2) Indicates main hydraulic system pressure when the standby hydraulic pump is off and the hydraulic shutoff valve is open.

(3) Indicates combined main and thrust reverser standby hydraulic system pressures when the standby hydraulic pump is on, and the hydraulic shutoff valve is open.

M. Operation (See Figures 71-70 & 71-71)

(1) When the thrust reverser standby hydraulic pump is switched on and increasing hydraulic pressure builds up to 2500 (± 100) psig, the pressure switch contact closes and a blue indicating light located in the flight compartment comes on. The light remains on, until decreasing pressure at 2100 psig opens the pressure switch contact and the light goes off. Should, during operation, the pump fail or the pump motor case temperature exceed 400°F and open the thermal cut-out switch, the light will go off. Should an emergency develop after the pump has been switched off by the opening of the thermal cut-out switch, placing the pump control switch in the override position will allow the pump to continue running.

(2) When, during operation of the thrust reverser system the demand is such to rapidly deplete the reservoir fluid quantity, the spring in the vacuum breaker check valve lifts the poppet off its seat to vent the reservoir to atmosphere. This action prevents a vacuum buildup in the reservoir.

33. Engine Oil System - Description and Operation

A. Description (See Figure 71-72)

(1) The engine oil system is a self-contained high-pressure system which supplies lubrication to the main engine bearings and accessory drives. A scavenge system removes oil from the bearing compartments and accessories and returns the oil to the tank. A breather system interconnects the individual bearing compartments to the oil tank. The oil system pressure and temperature are regulated within specified limits. The oil system consists of a supply tank, pressure, scavenge, and breather system, and provisions for filtering and cooling the oil. System operating conditions are displayed in the flight compartment by oil quantity, pressure, and temperature indicators.

35. Distribution - Description and Operation

A. General

(1) The engine is equipped with a high-pressure oil system to lubricate and cool the engine bearings and accessory drives. Components consist of the main oil pump, main oil filter, five oil scavenge pumps, fuel/oil cooler, oil pressure relief valve, and external oil tubes.

(2) The main oil pump is located in the main accessory drive case. The pump supplies oil system pressure.

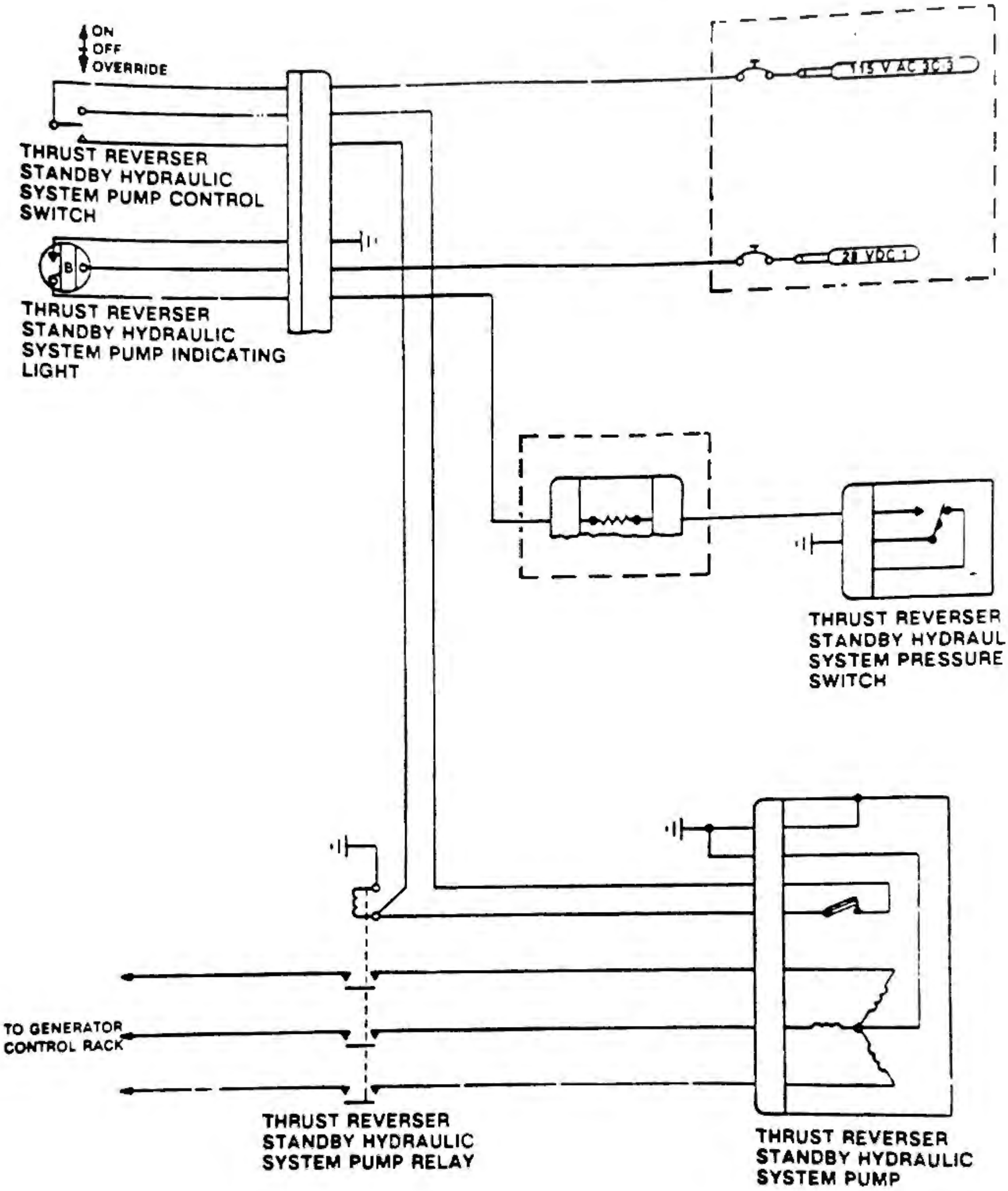
(3) The main oil filter is located forward, on the intermediate case flange. The filter removes contaminants from the oil downstream of the pressure pump.

(4) The five oil scavenge pumps are located within the inlet accessory drive case, main accessory drive case, diffuser case, and No. 6 bearing scavenge pump housing. The scavenge pumps return the oil to the tank via the fuel temperature regulator, and fuel/oil cooler.

(5) The fuel/oil cooler is mounted on the right side of the engine, aft of the fuel control. Cooling of the oil is accomplished by using engine high-pressure fuel as a heat exchange medium.

(6) The oil pressure relief valve (see figures 71-74 & 71-75) is located on the lower right side of the main accessory drive case. The valve controls oil system pressure between 40 and 55 psig, at the engine bearings.

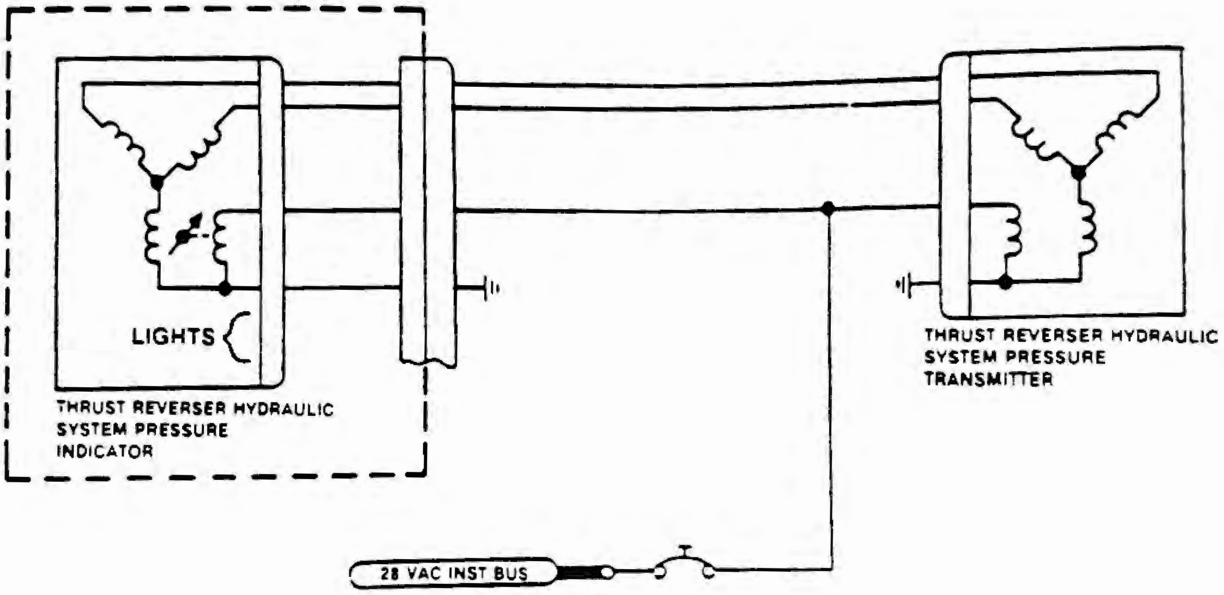
(7) The external tubes consist of pressure, scavenge, and breather tubes used to conduct lubricating oil to the engine bearings and oil system components.


ON
OFF
OVERRIDE
115 V AC 3C 3
THRUST REVERSER STANDBY HYDRAULIC SYSTEM PUMP CONTROL SWITCH
B
28 VDC 1
THRUST REVERSER STANDBY HYDRAULIC SYSTEM PUMP INDICATING LIGHT
THRUST REVERSER STANDBY HYDRAULIC SYSTEM PRESSURE SWITCH
TO GENERATOR CONTROL RACK
THRUST REVERSER STANDBY HYDRAULIC SYSTEM PUMP RELAY
THRUST REVERSER STANDBY HYDRAULIC SYSTEM PUMP

THRUST REVERSER STANDBY
HYDRAULIC SYSTEM - SCHEMATIC

FTX80612

Figure 71-70


LIGHTS
THRUST REVERSER HYDRAULIC SYSTEM PRESSURE INDICATOR
THRUST REVERSER HYDRAULIC SYSTEM PRESSURE TRANSMITTER
28 VAC INST BUS

THRUST REVERSER HYDRAULIC SYSTEM
PRESSURE INDICATOR - SCHEMATIC

FTX80613

Figure 71-71

(2) The oil tank is mounted on the forward upper left side of the engine case and is secured by two straps.

(3) Oil system pressure is supplied by the main oil pump located within the main accessory drive case. The pump outlet pressure is regulated by a valve, to maintain a specified pressure under all operating conditions.

(4) The main oil filter is located forward, on the intermediate case flange. The filter removes contaminants from the oil downstream of the main oil pump.

(5) The breather system which connects the individual bearing compartments, ensures proper oil flow and maintains satisfactory scavenge pump performance by controlling the pressure in the bearing cavities.

(6) The scavenge oil system includes five gear-type pumps which scavenge oil from the main bearing compartments and accessories, and returns the oil to the tank.

(7) Engine lubricating oil is cooled by the fuel/oil cooler mounted on the right side of the engine.

(8) The oil quantity indicating system consists of a float-type transmitter mounted in the engine oil tank and an indicator mounted on a panel in the flight compartment. The indicator registers oil quantity when the airplane electrical buses are energized.

(9) The oil pressure indicating system consists of a pressure transmitter mounted on the engine and an indicator mounted on a panel in the flight compartment. An indicating light, actuated by the oil low pressure caution switch mounted on the engine, comes on if the oil system operating pressure drops below the required minimum. The indicator registers pressure when the airplane electrical buses are energized.

(10) The main oil filter differential pressure system consists of a pressure switch mounted on the engine, and using the same indicating light provided for the oil low pressure caution switch. The pressure switch monitors the pressure differential between the main oil filter inlet and outlet. If the pressure across the filter becomes excessive, the pressure switch actuates the light to indicate filter clogging.

(11) The oil temperature indicating system consists of an indicator mounted on a panel in the flight compartment and a temperature sensor mounted on the main oil filter. The indicator registers temperature when the airplane electrical buses are energized.

B. Operation

Oil is gravity fed from the tank to the main oil pump where it is pumped through an internal passage of the main accessory drive case to the pressure relief valve. Oil flows through the valve and another internal passage of the main accessory drive case to the main oil filter where it is filtered through a stacked disc element. If filter clogging occurs, a bypass valve incorporated in the filter housing opens, allowing continuous oil flow. Oil flows from the filter into the inlet case where it is conducted through internal tubes, screens, metering orifices, and clearances, to the engine bearings and drives. As the bearings and drives are lubricated, cavities collect the excess oil. The scavenge pumps pump this oil through the scavenge tubes to the main accessory drive case sump. Oil is pumped from the sump through the fuel temperature regulator to the fuel/oil cooler. If the temperature of the oil is above 71.1°C (160°F), a bypass valve directs the oil through the fuel/oil cooler. If the oil temperature is below 60°C (140°F), the valve allows oil to bypass the fuel/oil cooler. Should the oil pressure across the fuel/oil cooler exceed 40 (±5) psi, a relief valve opens to allow the oil to bypass the fuel/oil cooler. Oil flows from the fuel/oil cooler to the oil tank and through the internal deaerator which removes the major part of the air collected from the system. Proper oil flow and scavenge pump operation is maintained by the breather system which balances the internal oil cavity pressure. The breather tubes conduct this pressure to the main accessory drive case where the oil-laden air passes through centrifugal breather impellers mounted on the fuel pump drive shaft, to remove the oil. The relatively oil-free air reaching the center of the drive shaft is vented overboard.

34. Storage - Description and Operation

A. General (See Figure 71-73)

(1) The engine oil tank is used to store and supply oil to the engine oil pump and lubricating system. The tank is of stainless steel, supported by stiffening posts welded to ferrules. The tank is mounted on the forward upper left side of the engine case and is secured by two straps. Flanges for vent, inlet, and drain line connections are located

on the top right and right sides of the tank respectively. The tank is provided with a self-locking filler cap with dipstick, internal baffle, internal deaerator, and three flanges at the bottom of the tank for the drain valve, oil quantity transmitter, and oil outlet connection.

(2) The self-locking filler cap with attached dipstick is located in a well at the upper right corner of the tank.

(3) An internal baffle is installed in the tank to minimize oil sloshing.

(4) The internal deaerator separates air from oil returned to the tank, the air being vented through the tank vent line into the diffuser. The deaerator is so located that the outlet is submerged even at low oil levels, preventing reaeration of the oil.

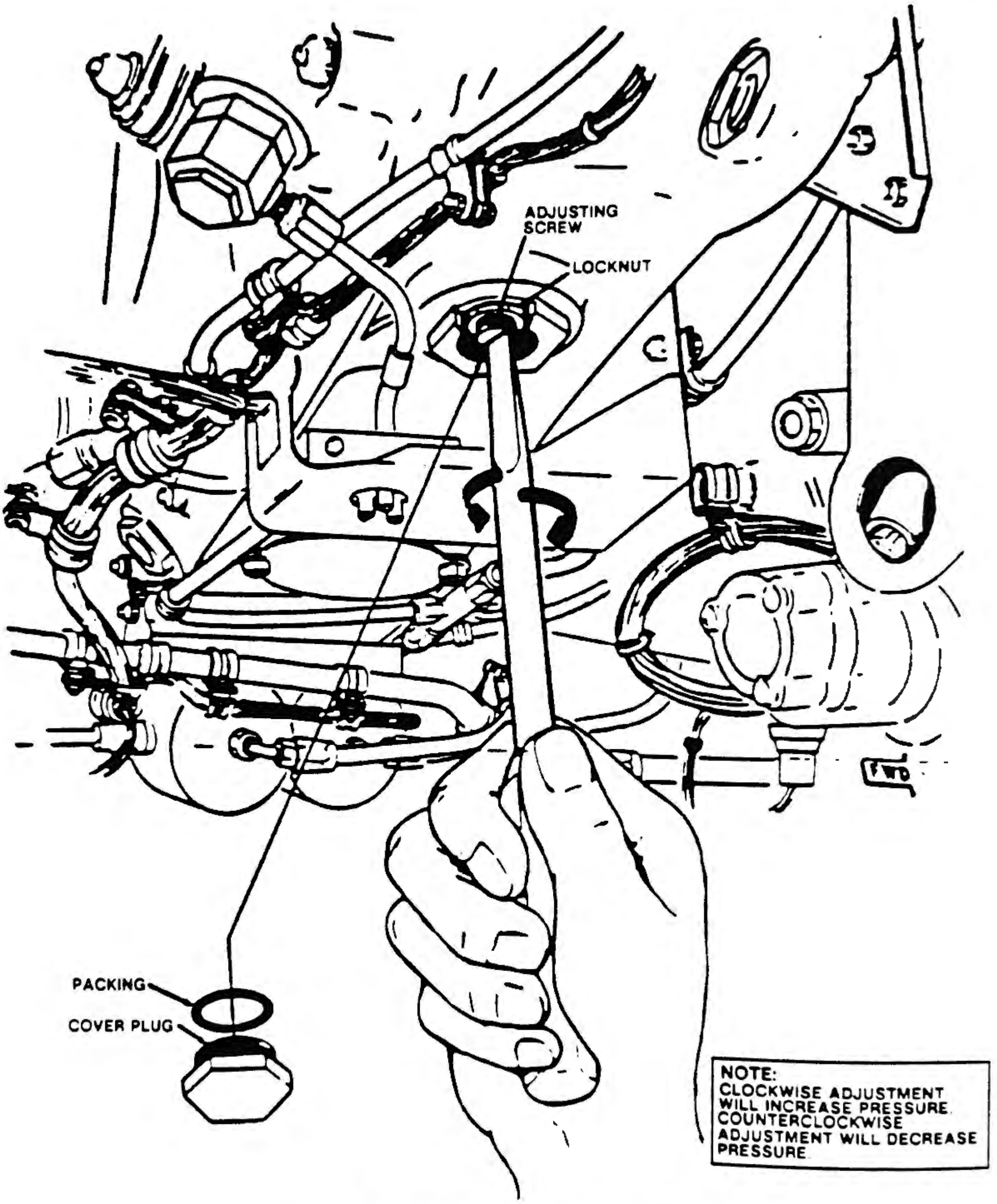
(5) A flange on the bottom left of the oil tank accommodates an oil quantity transmitter.

(6) The drain valve is located on the bottom right side of the oil tank. The handle of the valve is spring loaded to the valve closed position. Rotating the handle 90 degrees counterclockwise opens the valve and locks the handle in the open position with a ball detent. Clockwise movement of the handle unseats the ball from detent and allows spring tension to return the handle to the valve-closed position.

	US GALLONS
TOTAL CAPACITY	5.76
TOTAL USABLE ENGINE OIL	5.2
EXPANSION SPACE (APPROXIMATELY 28 PERCENT)	1.64
SUMP	0.14

ENGINE OIL STORAGE

Figure 71-73 FTX80615



NOTE:
CLOCKWISE ADJUSTMENT WILL INCREASE PRESSURE. COUNTERCLOCKWISE ADJUSTMENT WILL DECREASE PRESSURE.

OIL PRESSURE RELIEF VALVE

Figure 71-74

FTX80616

*OIL PRESSURE (PSIG)	OIL TEMPERATURE (°CENTIGRADE)
49.9	70
49.4	75
49.0	80
48.5	85
48.0	90
47.6	95
47.2	100
46.7	105
46.3	110
45.8	115
45.4	120

*(± 1 PSIG)

SHOULD DIFFICULTY BE EXPERIENCED IN FINE ADJUSTMENT OF THE ABOVE OIL PRESSURE AND OIL TEMPERATURES, THE OIL PRESSURE AND OIL TEMPERATURE RANGES ON THE FOLLOWING PAGE MAY BE USED.

CAUTION: DO NOT USE PROCEDURES OUTLINED IN STEPS (8) AND (9) AS OIL PRESSURE OR TEMPERATURE LIMITS. SEE CHAPTER 71 FOR ENGINE OIL PRESSURE OR TEMPERATURE LIMITS.

*OIL PRESSURE (PSIG)	OIL TEMPERATURE (°CENTIGRADE)
49-50	80-70
47-48	105-80
45-46	126-110

*(± 1 PSIG)

FTX80617

Figure 71-75

36. Fuel/Oil Cooler - Description and Operation

B. General (See Figure 71-76)

(1) Engine lubricating oil is cooled by the fuel/oil cooler mounted on the right side of the engine. The fuel/oil cooler accomplishes cooling of the oil by using engine high-pressure fuel as a heat exchange medium.

(2) The fuel/oil cooler consists of a cylindrical shaped steel housing assembly, temperature regulating valve, thermostatic valve, upper and lower covers, O-rings, and a gasket.

C. Operation

During engine operation, heated oil from the engine is directed into the fuel/oil cooler and flows through the center of the core where it is cooled by fuel passing through the outer jacket of the core. Heat from the oil is passed to the fuel by radiation. Oil below the operating temperature is prevented from entering the fuel/oil cooler by the thermostatic valve located at the oil inlet. This oil is bypassed back to the oil tank. The temperature regulating valve maintains the engine oil at an operating temperature of 155° to 195°F (68.3 to 90.6°C).

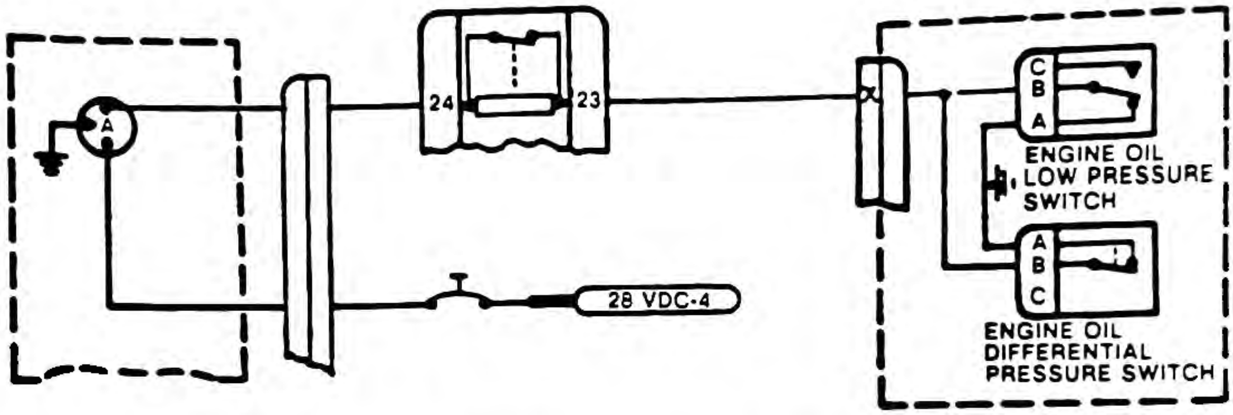
36. Indicating - Description and Operation

A. General

(1) Engine oil system operating conditions are displayed in the flight compartment by oil quantity, pressure, and temperature indicating systems.

(2) The engine oil quantity indicating system provides a remote indication of oil quantity. The system consists of a flat-type transmitter mounted on the oil tank, and an indicator mounted on a panel in the flight compartment. The system is with 28 VDC from DC bus 1 or 4.

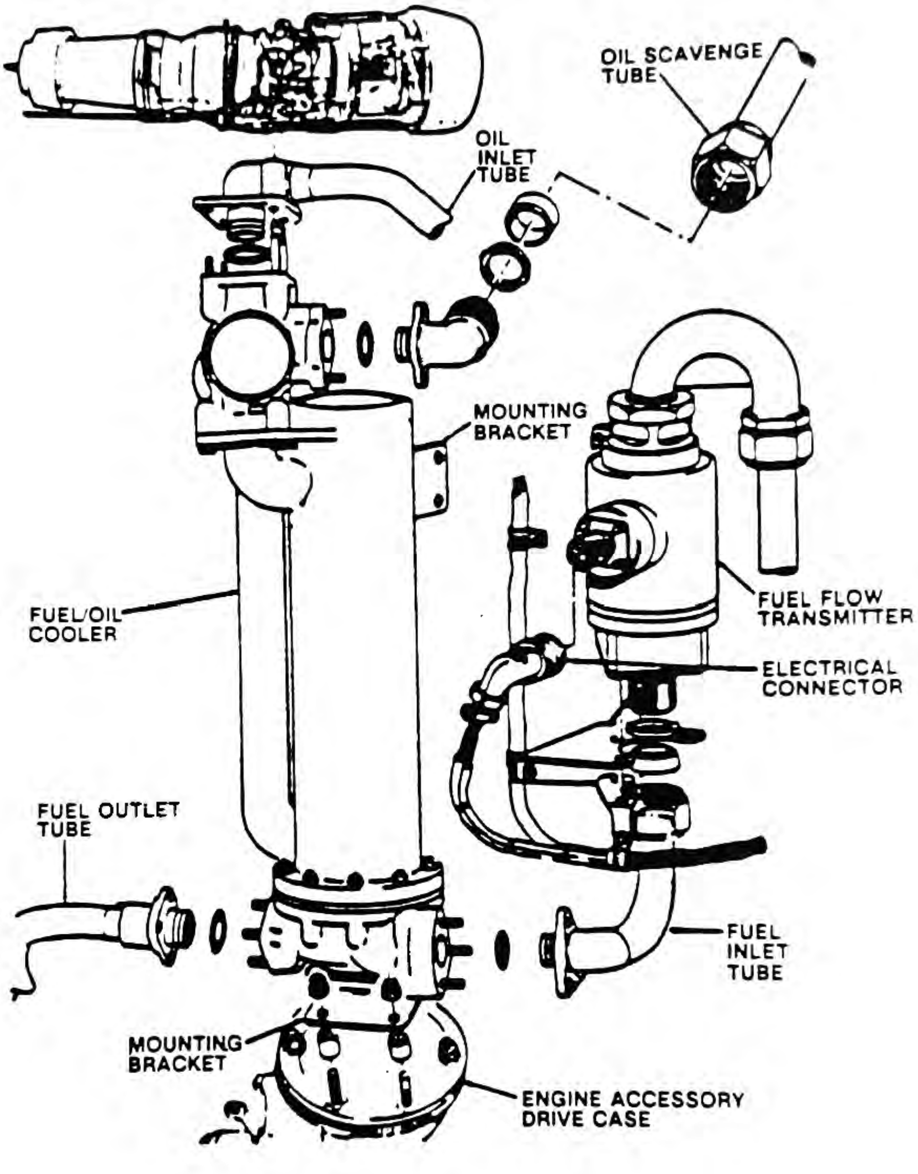
(3) The engine oil pressure indicating system consists of a transmitter mounted on the engine and an indicator mounted on a panel in the flight compartment. The system is supplied with 28 VAC from instrument bus 2 or 3.


A
24
23
28 VDC-4
C
B
A
ENGINE OIL LOW PRESSURE SWITCH
A
B
C
ENGINE OIL DIFFERENTIAL PRESSURE SWITCH

ENGINE OIL DIFFERENTIAL PRESSURE SYSTEM

FTX80621

Figure 71-79



FUEL/OIL COOLER INSTALLATION

FTX80618

Figure 71-76

(4) The low-pressure caution system consists of a pressure switch mounted on the engine and an indicating light mounted on a panel in the flight compartment. The system is supplied with 28 VDC from DC bus 1 or 4.

(5) The engine oil differential pressure system provides a remote indication of main oil filter obstruction. The differential pressure switch mounted on the engine uses the same indicating light provided for the oil low pressure caution switch. The system is supplied with 28 VDC from DC bus 1 or 4.

(6) The oil temperature indicating system provides a display of the oil system temperature. The system consists of a temperature sensor mounted on the main oil filter and an indicator mounted on a panel in the flight compartment. The system is supplied with 28 VDC form DC bus 1 or 4.

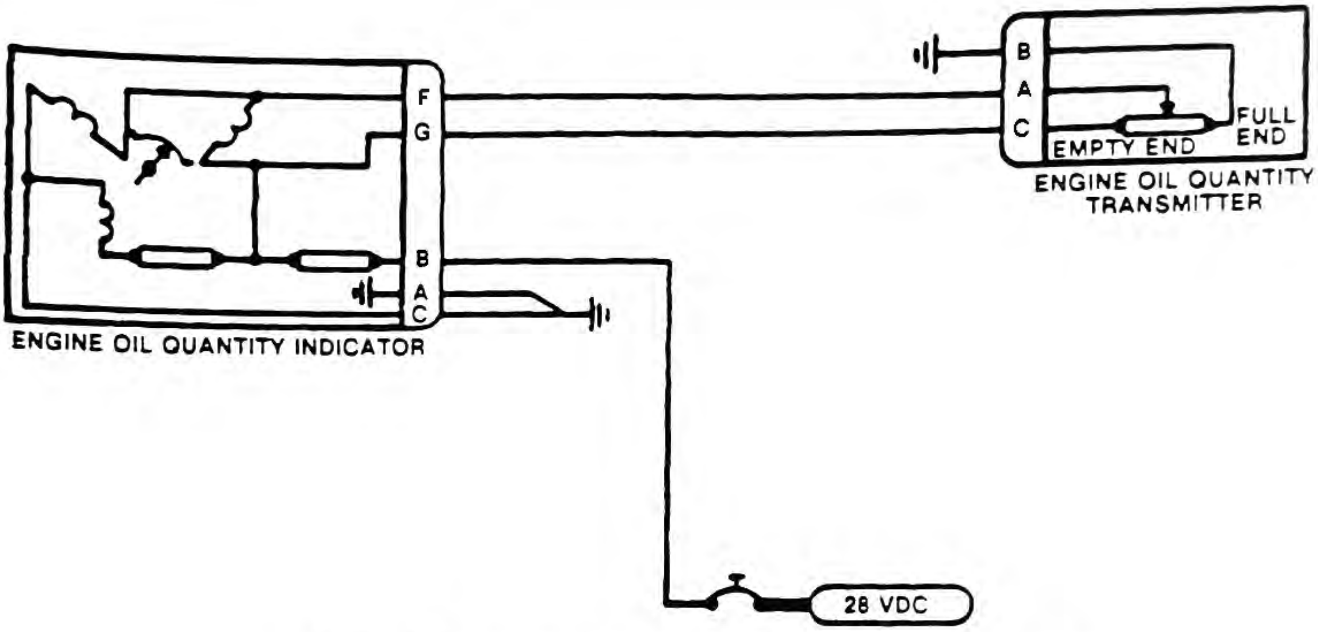
37. Engine Oil Quantity Indicating System - Description and Operation

A. General (See Figure 71-77)

(1) The engine oil quantity system provides a remote indication of oil quantity. The system consists of a transmitter mounted on the oil tank, and an indicator mounted on a panel in the flight compartment. The system is supplied with 28 VDC from DC bus 1 or 4 through a circuit breaker located on the main circuit breaker panel. The system is in operation when the electrical buses are energized. If the power source is interrupted, the indicator point goes against the stop past empty.

(2) The transmitter is a potentiometer-type unit containing a hermetically sealed fixed wire resistance strip, and a shorting strip with closely spaced flexible fingers which serves as a wiper, and a float with an integral permanent magnet.

(3) The indicator is an integrally lighted, hermetically sealed case containing three stationary coils, resistors for calibration and overload protection, and a permanent magnet rotor connected to a pointer. The indicator is not adjustable at field maintenance level. The indicator should read 0 (± 0.25) U.S. gallon when the oil tank is empty and 5 (± 0.25) U.S. gallons when full.


F
G
B
A
C
ENGINE OIL QUANTITY INDICATOR
B
A
C
FULL END
EMPTY END
ENGINE OIL QUANTITY TRANSMITTER
28 VDC

ENGINE OIL QUANTITY INDICATING SYSTEM

FTX80619

Figure 71-77

B. Operation

As the oil level in the tank changes, the transmitter float magnetically actuates the wiper contact fingers which vary the resistance as in a linear potentiometer. One side of the output is connected to the full coil of the indicator, the other side is connected to the empty coil. When the tank is full, maximum current flows to the full coil, causing the rotor to pull the pointer to the full position. As the oil level goes down, the float drops, decreasing current flow to the full coil and increasing current flow to the empty coil. This causes the rotor to pull the pointer to a lower position. As current flow to the empty coil increases,the rotor and pointer continue moving away from the full position until maximum current flow pulls the pointer to the empty position.

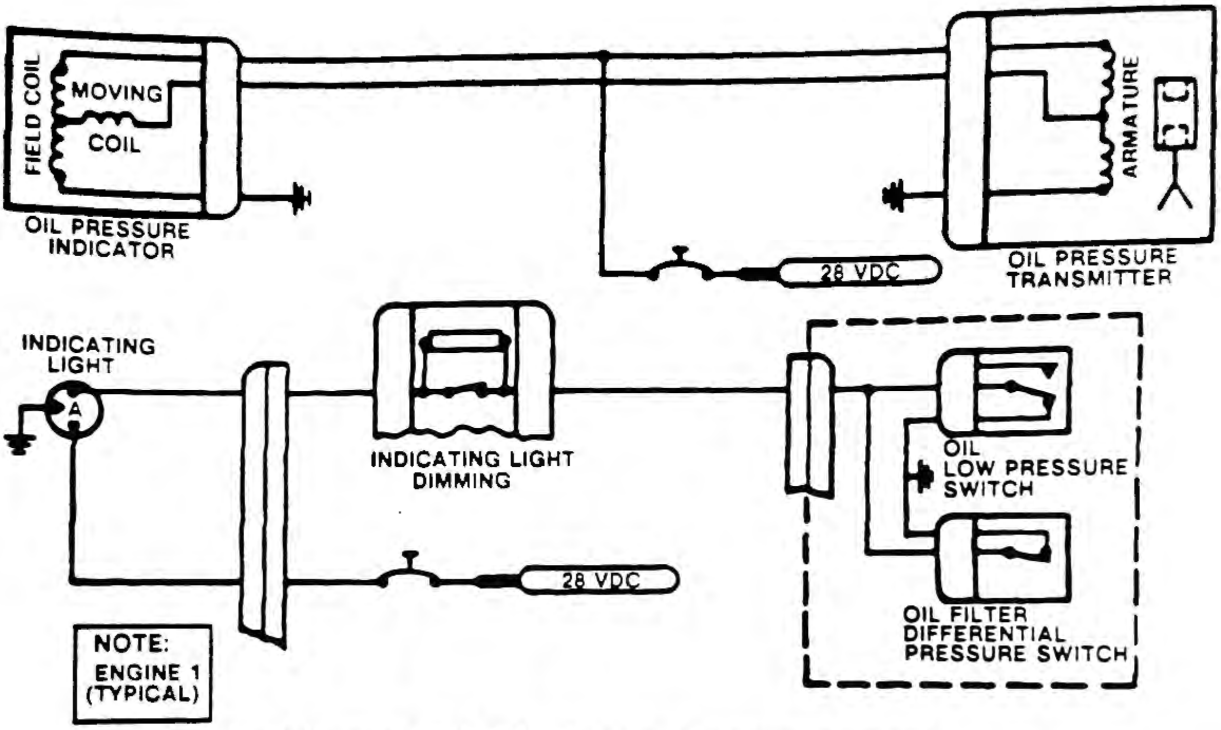
38. Engine Oil Pressure Indicating System - Description and Operation

A. General (See Figure 71-78)

(1) Engine oil pressure indicating systems include oil pressure indicating, and oil low-pressure caution. The oil pressure indicating system consists of a transmitter mounted on the main oil filter and in indicator mounted on a panel in the flight compartment. The system is supplied with 28 VAC from instrument bus 2 or 3 through a circuit breaker located on the main circuit breaker panel. The system is in operation when the airplane electrical buses are energized. If the power source is interrupted, the indicator pointer goes against the stop past zero.

(2) The transmitter is a variable reluctance type consisting of a diaphragm, magnetic armature, two stationary coils, and a housing. The housing is provided with a pressure port, vent port, electrical connector, and a removable plug cap which permits access for calibration adjustments.

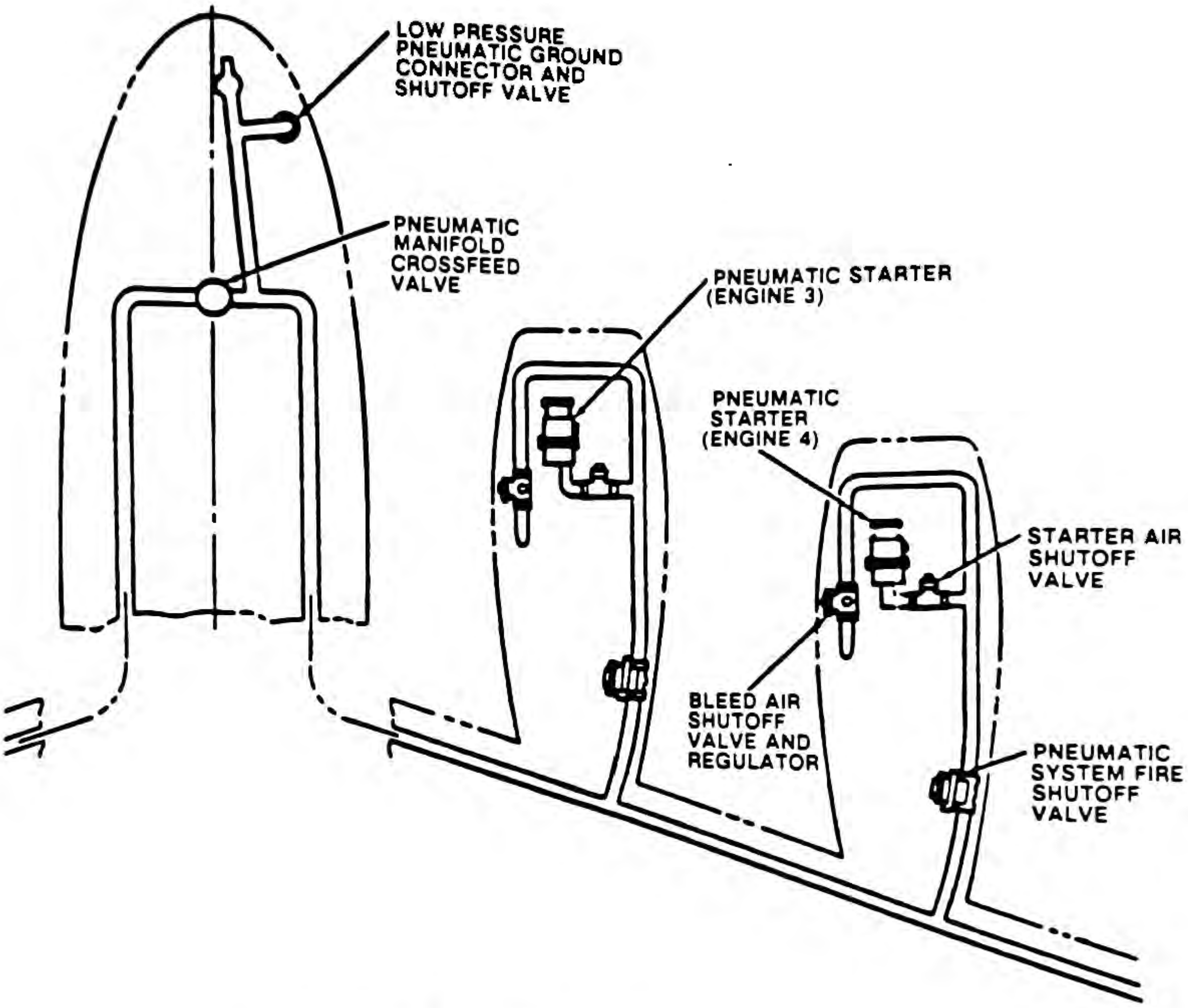
(3) The indicator is integrally lighted and hermetically sealed, and consists of a stationary coil, rotor and hairspring assembly connected to a pointer, bearings, resistors, and thermistors. The indicator is not adjustable at field maintenance level.



ENGINE OIL PRESSURE INDICATING SYSTEM

FTX80620

Figure 71-78


LOW PRESSURE PNEUMATIC GROUND CONNECTOR AND SHUTOFF VALVE
PNEUMATIC MANIFOLD CROSSFEED VALVE
PNEUMATIC STARTER (ENGINE 3)
PNEUMATIC STARTER (ENGINE 4)
STARTER AIR SHUTOFF VALVE
BLEED AIR SHUTOFF VALVE AND REGULATOR
PNEUMATIC SYSTEM FIRE SHUTOFF VALVE

PNEUMATIC STARTING SCHEMATIC

FTX80624

Figure 71-82

(4) The low-pressure caution system consists of a pressure switch mounted on the engine and an indicating light mounted on a panel in the flight compartment. The system is supplied with 28 VDC from DC bus 1 or 4 through a circuit breaker located on the main circuit breaker panel.

(5) The low-pressure switch is hermetically sealed, pressure actuated, and consists of a diaphragm, mechanical linkage, switch, and a housing. The housing is provided with a pressure port, vent port, and an electrical connector.

B. Operation

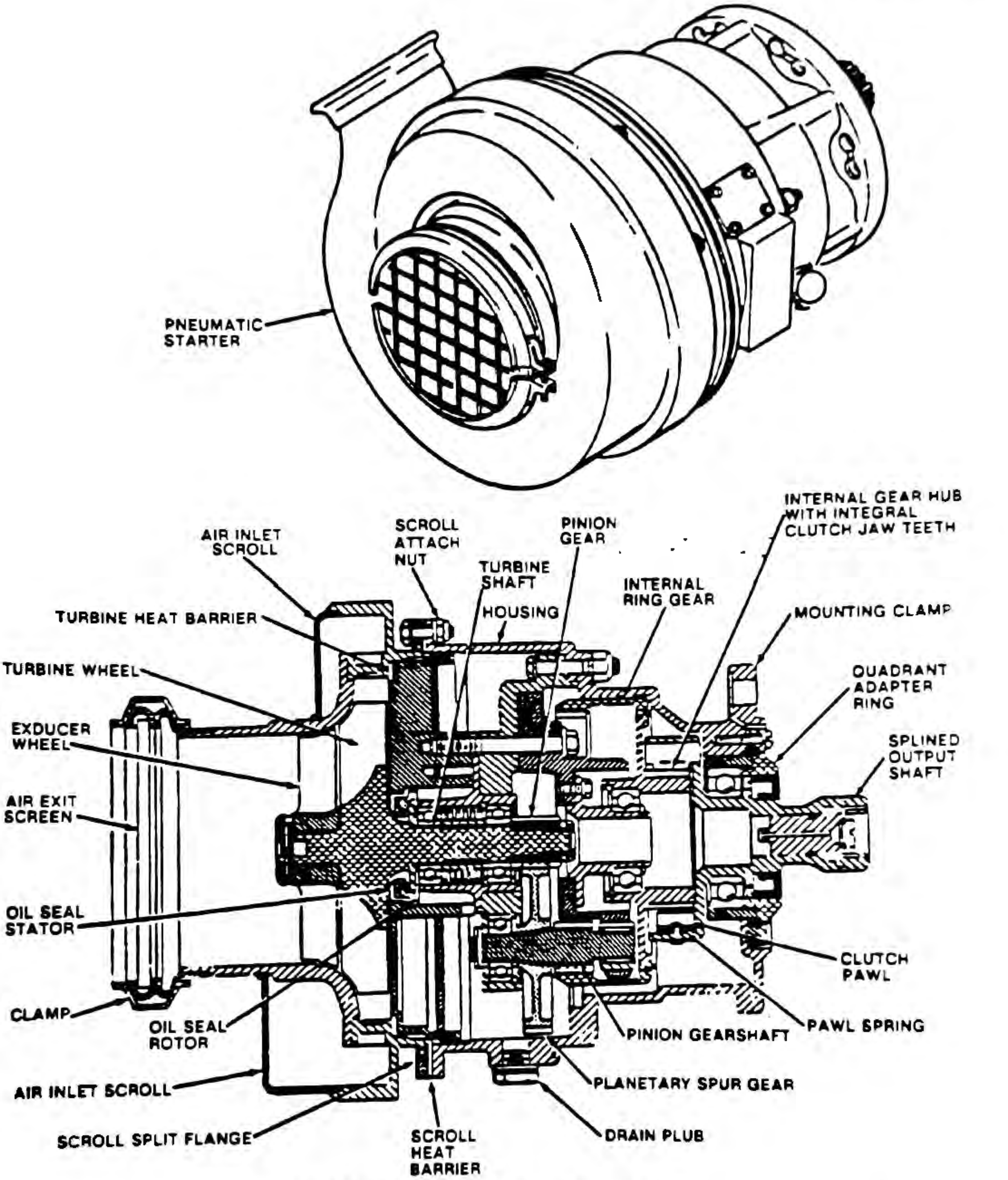
(1) The oil pressure transmitter and oil low-pressure caution switch sense the engine oil system pressure downstream of the oil cooler. The oil pressure transmitter and indicator function as an AC bridge. Any change in pressure sensed by the transmitter causes the diaphragm to move the armature, changing the reluctance of the transmitter coils. This change in reluctance unbalances the bridget network, creating a greater current flow in one side of the bridge. The current flow in the circuit results in movement of the indicator rotor and pointer.

(2) The oil low-pressure caution indicating light is normally on until an increasing pressure of 40 psi is obtained, at which time, the switch contacts open and the light goes off. When the system pressure decreases to 36 (±1) psi, the switch contacts close completing a circuit, and the light comes on.

39. Engine Oil Differential Pressure System - Description and Operation

A. General (See Figures 71-79 & 71-80)

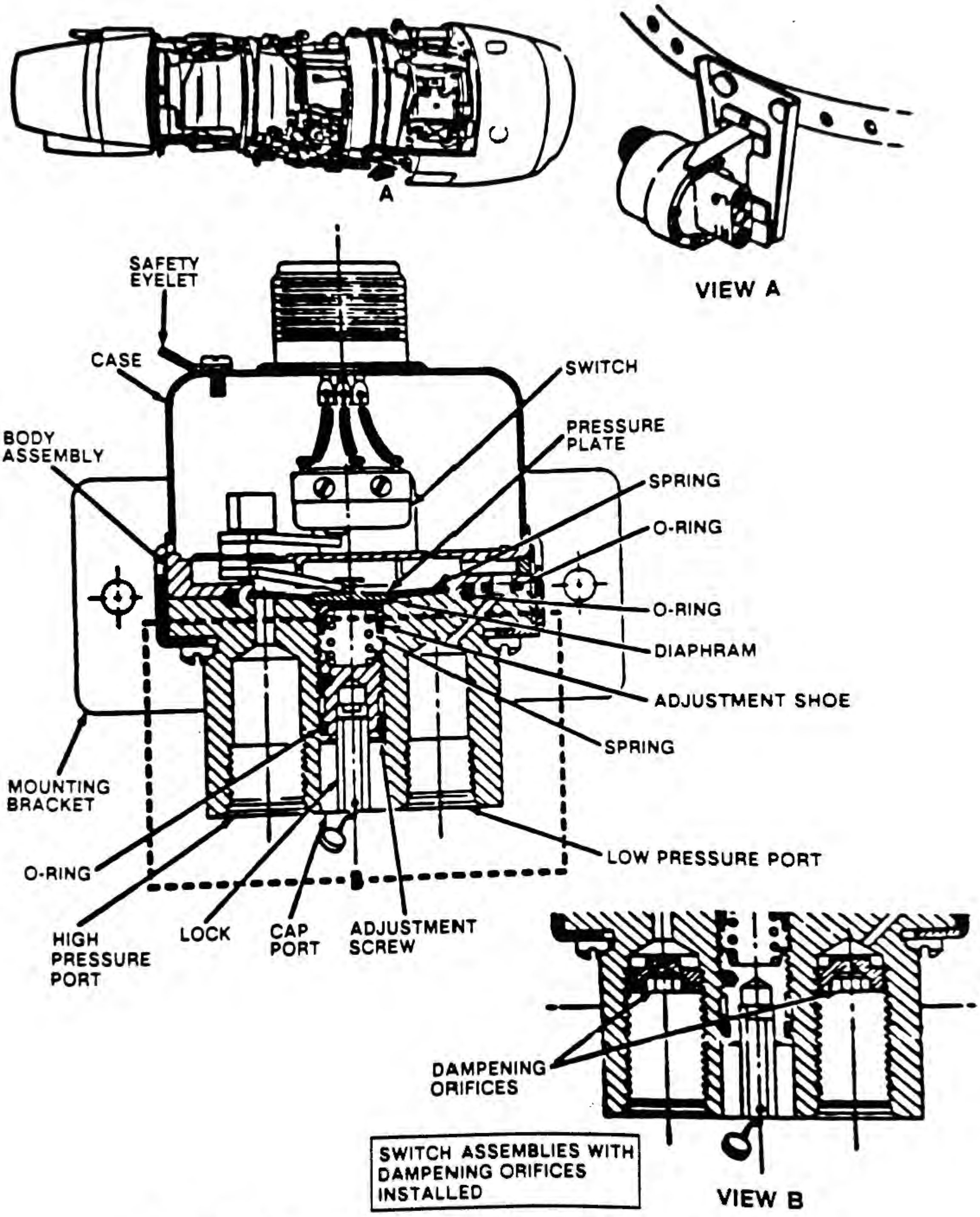
(1) The engine oil differential pressure system provides a remote visual indication of main oil filter obstruction. The system consists of a differential pressure switch mounted on the engine and an indicating light mounted on a panel in the flight compartment. The system is supplied with 28 VDC from DC bus 1 or 4 through a circuit breaker, located on the main circuit breaker panel.



LOW PRESSURE STARTER SCHEMATIC

FTX80626

Figure 71-84



SWITCH ASSEMBLIES WITH DAMPENING ORIFICES INSTALLED

ENGINE OIL DIFFERENTIAL PRESSURE SWITCH

FTX80622

Figure 71-80

(2) The differential pressure switch measures the pressure differential between the main oil filter inlet and outlet. The pressure switch is hermetically sealed, pressure actuated, and consists of a diaphragm, mechanical linkage, and a switch contained within a housing. The housing is provided with two pressure sensing connections and an electrical connector.

B. Operation

When the differential pressure across the main oil filter reaches 50 (±1.5) psi, the pressure switch diaphragm and mechanical linkage actuates the switch to the closed position. A circuit is completed and an indicating light comes on signaling filter obstruction. On decreasing pressure to below 44 psi, the indicating light goes off.

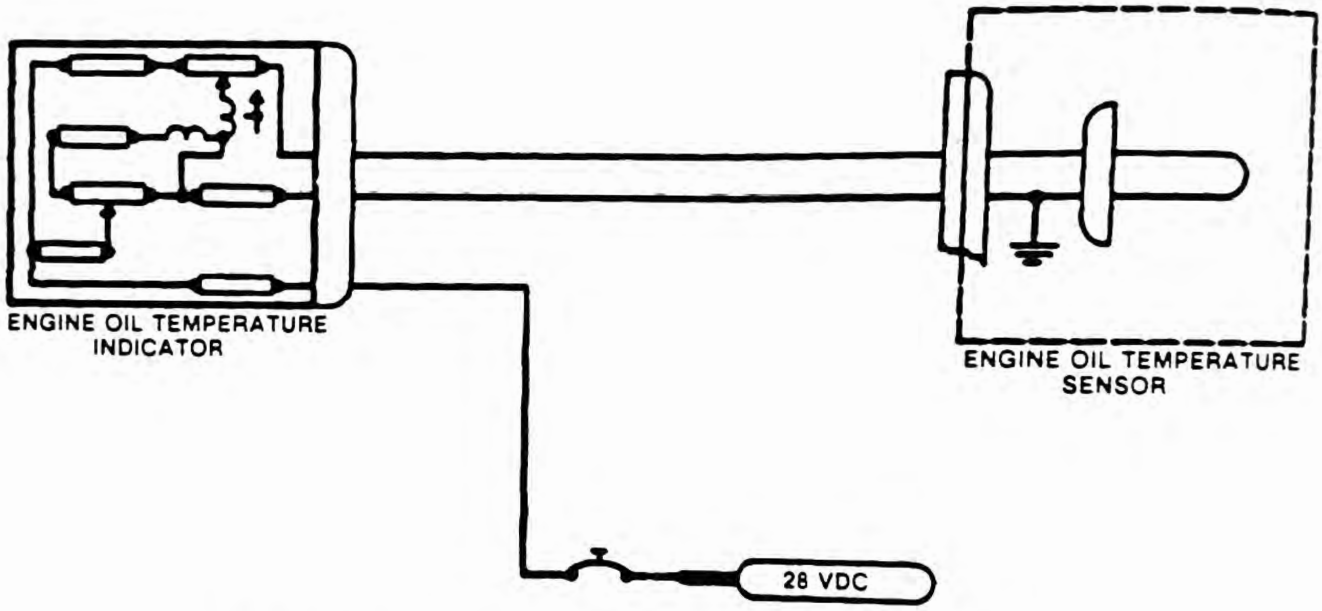
40. Engine Oil Temperature Indicating System - Description and Operation

A. General (See Figure 71-81)

(1) The engine oil temperature indicating system provides a visual display of the oil system temperature. The system consists of a temperature sensor installed on the main oil filter mounted forward on the intermediate case flange, and an indicator mounted in the flight compartment. The system is powered by 28 VDC from DC uses 1 and 4 through circuit breakers located on the main circuit breaker panel. The system is in operation when the airplane electrical buses are energized. If the power source is interrupted, the pointer goes against the stop past zero.

(2) The temperature sensor is a resistance-type bulb that consists of an element hermetically sealed in an insulating material within a housing. The housing is provided with an electrical connector and external mounting threads.

(3) The indicator is a DC ratiometer-type, integrally lighted, hermetically sealed, and consists of a permanent magnet field core assembly and armature assembly connected to a pointer, springs, resistors, and calibration potentiometers. The indicator is not adjustable at field maintenance level.


ENGINE OIL TEMPERATURE INDICATOR
ENGINE OIL TEMPERATURE SENSOR
28 VDC

ENGINE OIL TEMPERATURE INDICATING SYSTEM

FTX80623

Figure 71-81

B. Operation

When supplied with 28 VDC, the indicator operates on the Wheatstone bridge principle with the temperature sensor forming one arm of the bridge circuit. A change in engine oil temperature sensed by the sensor causes a change in resistance. This change in resistance unbalances the bridge, creating a greater current flow in one side of the bridge. The increase in current flow results in movement of the indicator pointer which registers oil temperature.

41. Engine Starting - Description and Operation

A. Description (See Figure 71-82)

(1) The engine starting system converts pneumatic energy into shaft torque sufficient to accelerate the engine to starting speed. The system consists of an air turbine starter, a starter air shutoff valve, and a starter and ignition switch. In addition, a starter air shutoff valve position indicating light is installed in the flight compartment.

(2) Electrical power to energize the starter air shutoff solenoid is supplied by the 28-VDC battery bus. The bus is energized either by the airplane battery or an external power source.

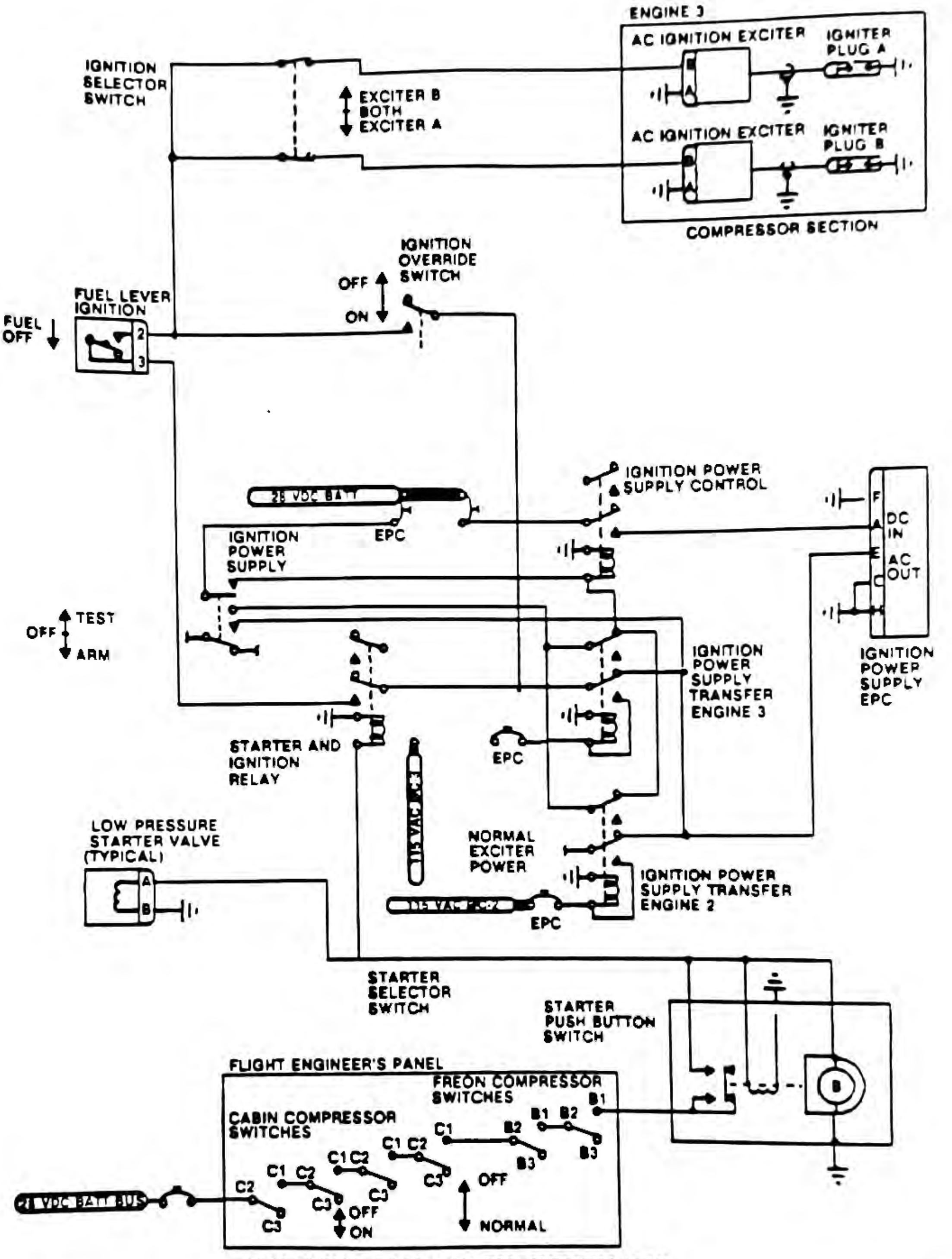
(3) Pneumatic power to operate the starter may be obtained from the following sources:

(a) The airplane pneumatic system when one engine is running.

(b) An external pneumatic supply source connected to the fuselage pneumatic ground connector.

B. Operation

Engine starting is initiated when the airplane electrical buses are energized, starting system armed, starter air shutoff valve opened, and pneumatic pressure supplied to the starter. Air entering the starter is directed to propel the starter turbine to high-speed rotation which is converted to shaft torque to accelerate the engine to starting speed. When engine lightoff occurs, the starter air shutoff valve is closed to terminate the starting cycle.



STARTING ELECTRICAL SCHEMATIC

FTX80628

Figure 71-87

C. To Operate System

(1) Preparation

(a) To assure an acceptable start, when using the airplane low-pressure pneumatic system, the following minimum readings (see Figure 71-83) should be obtained form the airplane manifold air temperature and air pressure indicators.

NOTE: Subtract 0.7 psig for every 1000 feet increase in pressure altitude.

(b) To assure an acceptable start using a ground pneumatic cart connected to the fuselage nose ground pneumatic connector, the following minimum readings (see Figure 71-83) should be obtained from the ground pneumatic cart air temperature indicator and the ground pneumatic cart air pressure indicator.

NOTE: Subtract 0.7 psig for every 1000 feet increase in pressure altitude.

42. Cranking - Description and Operation

A. General

(1) Low Pressure Pneumatic Starting System

(a) A minimum pneumatic pressure supply of 30.5 psig and electrical source of 28 VDC are required when using the low-pressure pneumatic system to crank the engine. Major components of the system are the low-pressure pneumatic starter and starter air shutoff valve located on the left side of each engine, and starter pushbutton control switch located in the flight compartment. A starter air shutoff valve position indicating light is also located in the flight compartment.

(b) The low-pressure starter (see Figure 71-84) is a single-stage, air turbine motor used to convert kinetic energy of high-temperature compressed air into starting torque sufficient to accelerate the engine to starting speed. The starter consists of a turbine wheel and scroll, reduction gear train and overrunning clutch, splined output shaft, and housing.

AIRPLANE MANIFOLD AIR TEMPERATURE	MINIMUM RECOMMENDED MANIFOLD AIR PRESSURE (AT SEA LEVEL)	MINIMUM ALLOWABLE MANIFOLD AIR PRESSURE (AT SEA LEVEL)
149°C (300°F)	30 PSIG	27 PSIG
121°C (250°F)	30 PSIG	28 PSIG
93°C (200°F)	30 PSIG	28 PSIG
66°C (150°CF)	30 PSIG	28 PSIG
38°C (100°F)	31 PSIG	31 PSIG

NOTE: SUBTRACT 0.7 PSIG FOR EVERY 1000 FEET INCREASE IN PRESSURE ALTITUDE.

TO ASSURE AN ACCEPTABLE START USING A GROUND PNEUMATIC CART CONNECTED TO THE FUSELAGE NOSE GROUND PNEUMATIC CONNECTOR, THE FOLLOWING MINIMUM READINGS SHOULD BE OBTAINED FROM THE GROUND PNEUMATIC CART AIR TEMPERATURE INDICATOR AND THE GROUND PNEUMATIC CART AIR PRESSURE INDICATOR.

GROUND PNEUMATIC CART MANIFOLD AIR TEMPERATURE	MINIMUM RECOMMENDED GROUND PNEUMATIC CART MANIFOLD AIR PRESSURE (AT SEA LEVEL)	MINIMUM ALLOWABLE GROUND PNEUMATIC CART MANIFOLD AIR PRESSURE (AT SEA LEVEL)
149°C (300°F)	35 PSIG	32 PSIG
121°C (250°F)	35 PSIG	33 PSIG
93°C (200°F)	35 PSIG	33 PSIG
66°C (150°CF)	35 PSIG	33 PSIG
38°C (100°F)	36 PSIG	36 PSIG

NOTE: SUBTRACT 0.7 PSIG FOR EVERY 1000 FEET INCREASE IN PRESSURE ALTITUDE.

PRESSURE REQUIREMENTS

FTX80625

Figure 71-83

(c) The starter air shutoff valve (see Figure 71-85) is electrically actuated and pneumatically operated. The valve controls the flow of air from the airplane low-pressure manifold to the starter. Components of the valve include a solenoid-controlled ball switcher valve, piston-type actuator, butterfly, air filter, and cam-actuated valve position indicator switch. The valve indicator switch closes to complete the indicating light circuit when the valve is in the open position.

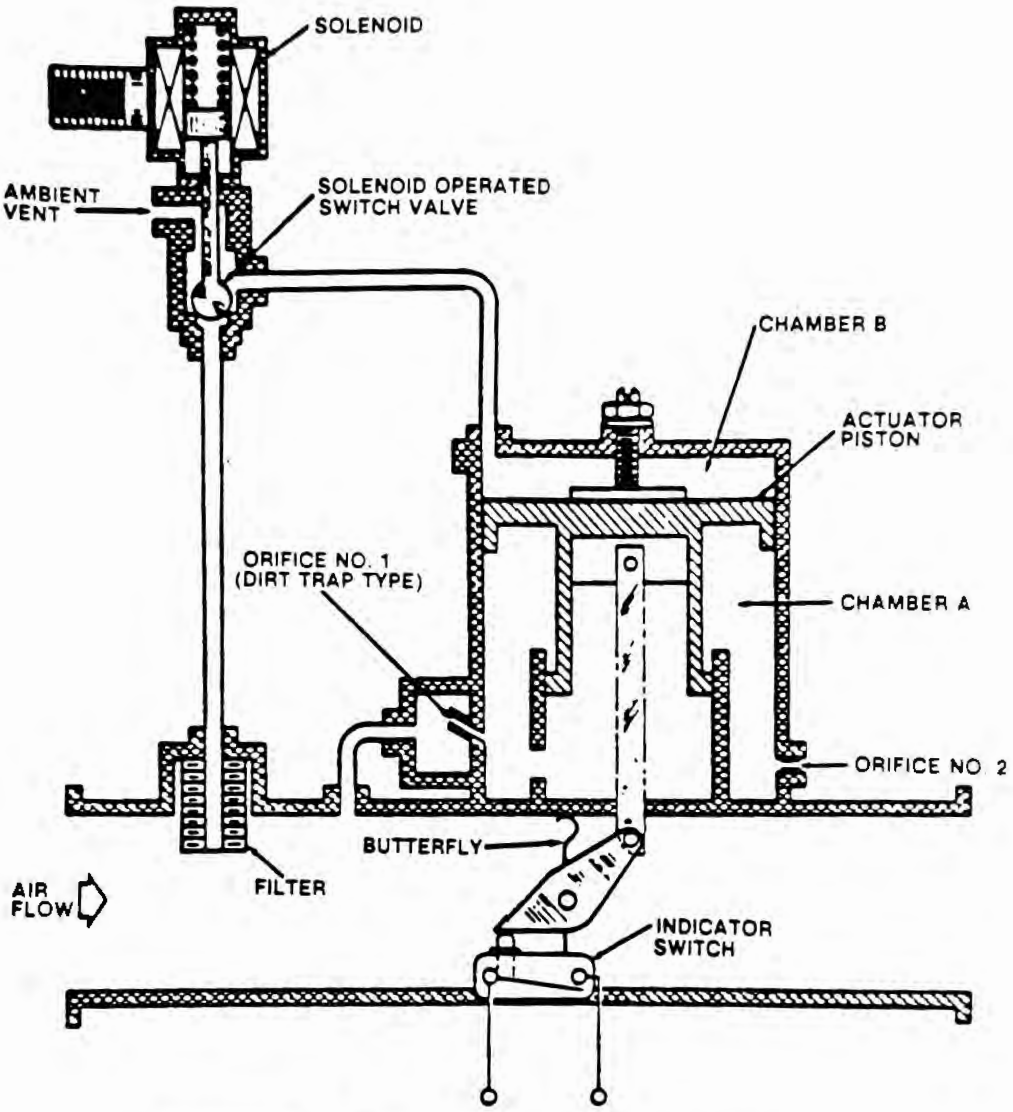
(d) The starter pushbutton control switch supplies power to the starter air shutoff valve solenoid and starter and ignition relay.

(e) The starter air shutoff valve position indicating light (see Figure 71-86), located in the flight compartment, comes on when the shutoff valve is in the open position.

B. Operation (See Figure 71-87)

(1) Engine cranking, utilizing the low-pressure starting system, is initiated when the system is armed and pneumatic pressure is supplied to the starter.

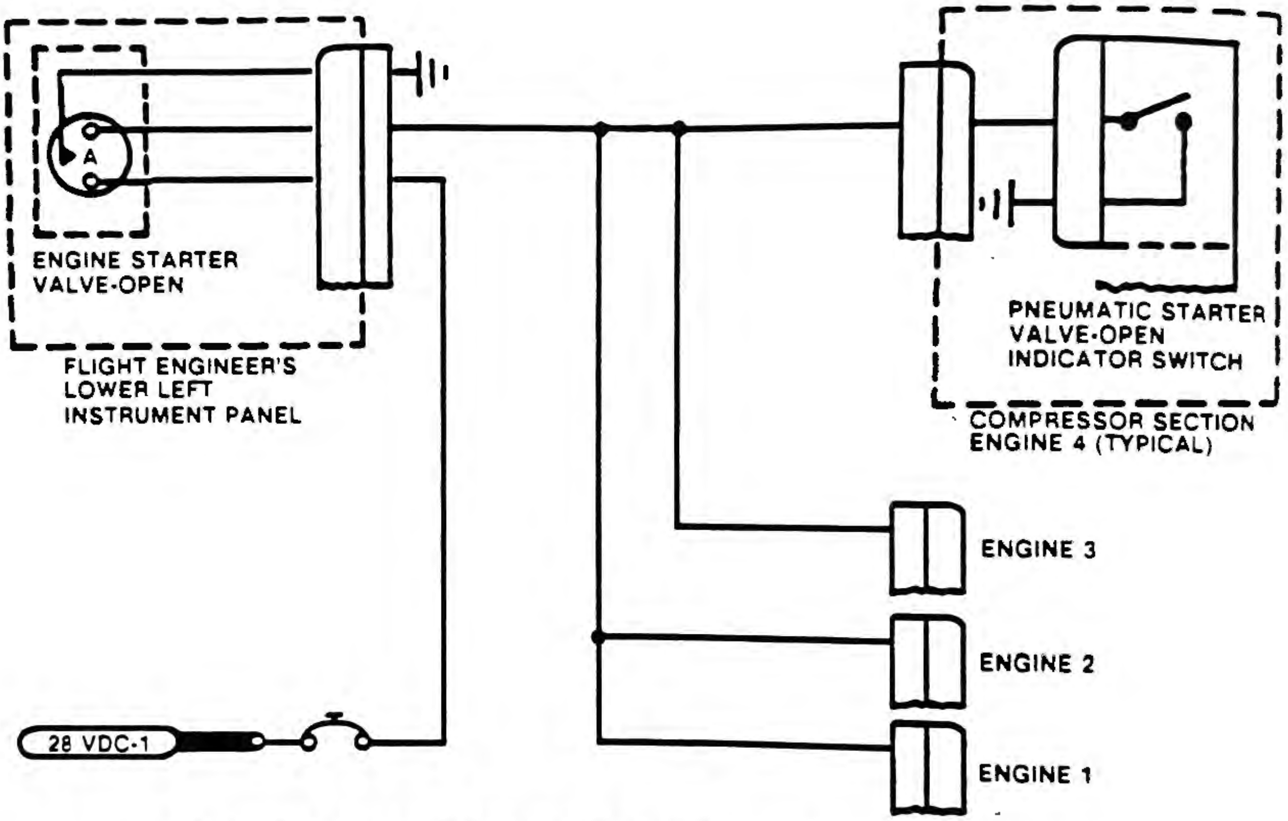
(2) When the starter pushbutton control switch depressed, the starter air shutoff valve solenoid is energized. Actuation of the shutoff valve solenoid permits air pressure to open the valve and pneumatic manifold air to flow to the starter. Air entering the starter passes through the stator vanes and is directed radially inward to propel the turbine to high-speed rotation. Expended air is vented into the engine compartment. Reduction gearing reduces the high-speed (low torque) rotation of the turbine wheel to low-speed (high torque) at the output shaft to accelerate the engine to starting speed. When engine lightoff occurs, the starter pushbutton control switch is released to terminate the starting cycle.



STARTER AIR SHUTOFF VALVE SCHEMATIC

FTX80627

Figure 71-85


A
ENGINE STARTER VALVE-OPEN
FLIGHT ENGINEER'S LOWER LEFT INSTRUMENT PANEL
PNEUMATIC STARTER VALVE-OPEN INDICATOR SWITCH
COMPRESSOR SECTION ENGINE 4 (TYPICAL)
ENGINE 3
ENGINE 2
ENGINE 1
28 VDC-1

ENGINE PNEUMATIC STARTER VALVE INDICATION

FTX80629

Figure 71-86

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DC-8
Maintenance
study guide
volume 2

1. General

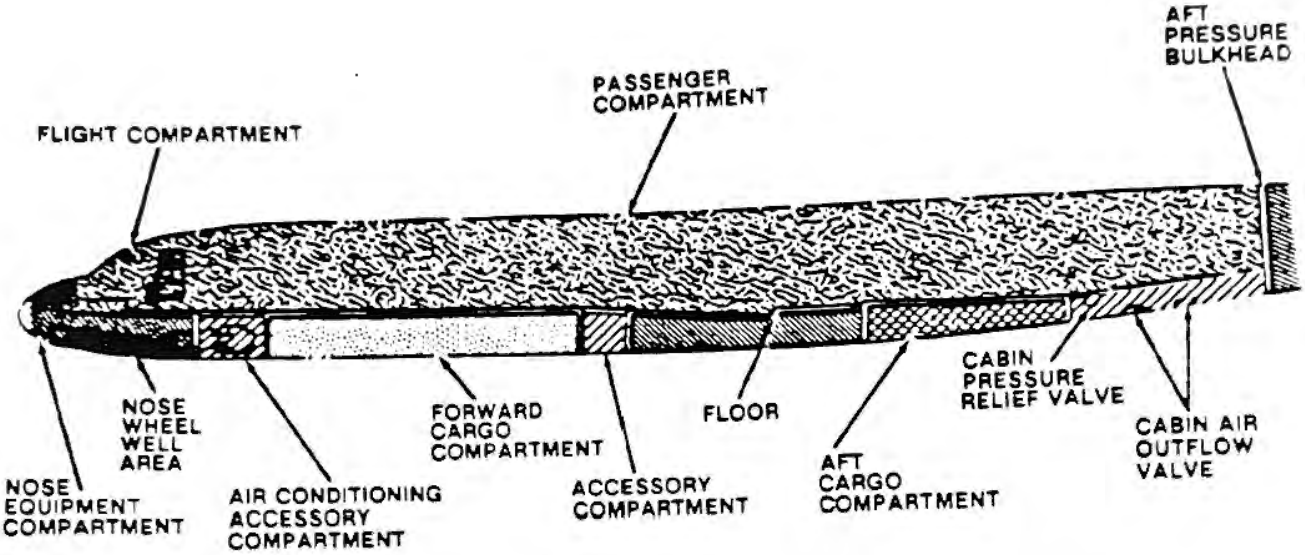
A. Description

The aircraft has two air conditioning systems (left and right) designed for independent operation. The left-hand system is the Douglas refrigeration system. The right-hand ABX supplemental refrigeration system replaces the original Douglas right-hand system which has been partially removed and deactivated.

The Douglas left-hand refrigeration system is designed to supply conditioned air, cold air, and pressurized air at a controlled volume and pressure. Fresh air supply for air conditioning and pressurization is supplied by four cabin compressors. The left-hand system normally provides automatic temperature control for the flight compartment and the cabin. Due to volume differences between the two areas, only a small portion of air is supplied to the flight compartment.

The ABX supplemental refrigeration system is used in lieu of the original Douglas right-hand refrigeration system. The system performs the cooling and dehumidification of cabin air. In this type of system, cabin air is passed over the evaporator and is cooled as heat is absorbed from this air by low pressure Refrigerant -12.

The flight compartment and cabin are the only areas directly supplied with pressurized, conditioned, and cold air. Pressurized areas are shown in Figure 21-1. The forward cargo compartment is heated by radio rack exhaust air circulated by the radio rack blower. The aft cargo compartment is heated by exhaust air circulated by the aft cargo compartment blower. Cargo compartment heating is accomplished by flowing air through the gap between the cargo compartment floor and the aircraft skin insulation. There is no continuous airflow through the cargo compartments. Cargo compartment pressure equalization valves are installed in the ceiling of each cargo compartment to maintain pressure within the compartments equal to cabin pressure. The flight compartment has a supplemental heater that is operated only on the ground, using external power or power supplied from the engine generators.



▧ PRESSURIZED AND AIR CONDITIONED BY AIR CONDITIONING SYSTEMS

▓ UNPRESSURIZED

▩ PRESSURIZED BY INTERMITTENT ACTION OF CARGO COMPARTMENT PRESSURE EQUALIZATION VALVES. HEATED BY PASSENGER COMPARTMENT EXHAUST AIR DUCTED THROUGH THE FLOOR BY THE AFT CARGO COMPARTMENT BLOWER, NO TEMPERATURE CONTROL.

☐ PRESSURIZED BY INTERMITTENT ACTION OF CARGO COMPARTMENT PRESSURE EQUALIZATION VALVES. MAY BE HEATED BY RADIO RACK EXHAUST AIR DUCTED THROUGH FLOOR.

▨ PRESSURIZED BY AIR EXHAUSTED FROM THE FLIGHT AND PASENGER COMPARTMENTS. NO TEMPERATURE CONTROL.

PRESSURIZED AREAS AND COMPARTMENT LOCATIONS

FTX80305

Figure 21-1

AIR CONDITIONING SYSTEM

The air conditioning system delivers conditioned air when the air conditioning systems are operating, but each function of the system is monitored and controlled by separate subsystems. To segregate these functions, air conditioning is divided into compression, distribution, pressurization control, heating, cooling, and temperature control (Figures 21-2 & 21-3).

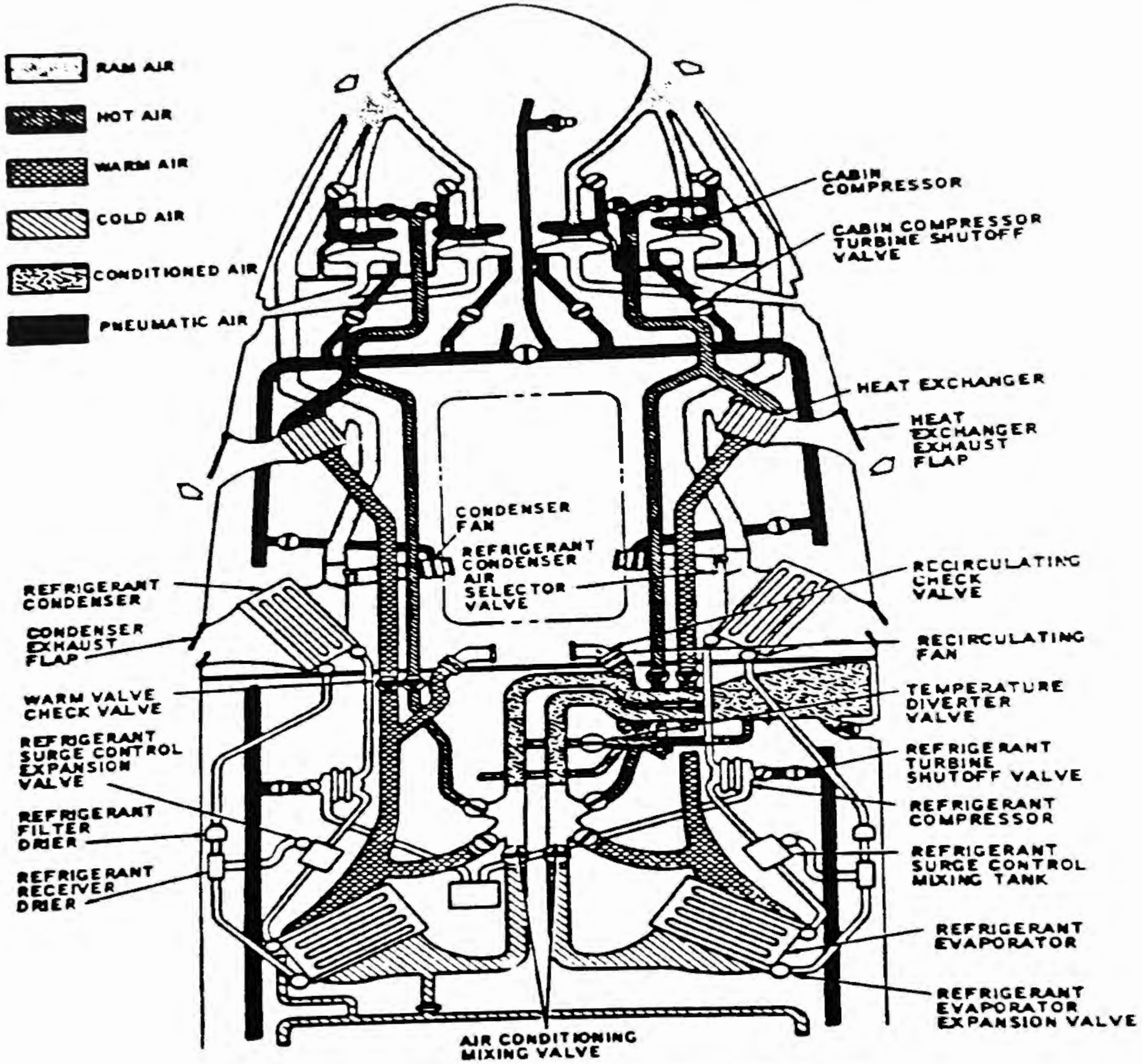
(1) Compression

(a) The four cabin compressors are the same size and capacity. the two compressors on the left side of the fuselage centerline normally supply air to the left (flight compartment) air conditioning system, and the two compressors on the right side of the fuselage normally supply air to the right (passenger compartment) air conditioning system. An electrical overspeed circuit is used to protect the compressors against overspeed conditions.

(b) Outside air for the compressors enters through ram airscoops located in the fuselage nose section. After passing through the compressors, the air can be further cooled or heated, as necessary, before distribution to the occupied areas of the airplane. Cabin compressor operation is controlled by switches located on the systems engineer control panel (Figure 21-4) in the flight compartment. Compressor operation is monitored by the cabin compressor rpm indicator, the oil overtemperature warning light, and an overspeed test pushbutton.

(2) Distribution (Figure 21-5)

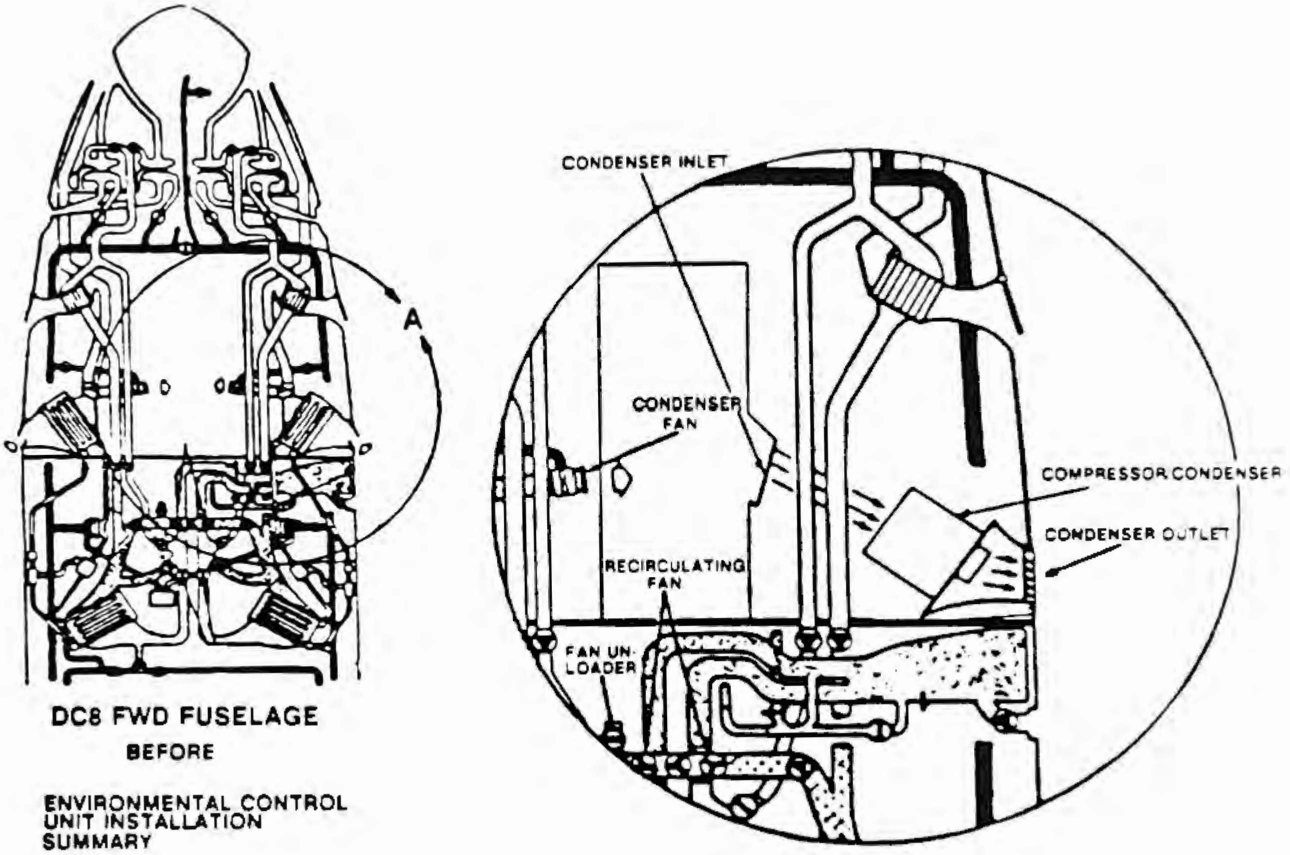
(a) The distribution system directs the flow of ram air, hot air, warm air, cold air, conditioned air, and exhaust air. The left-hand system normally supplies the small amount of conditioned air used by the flight compartment. The remainder of the air from the left-hand system is combined with the right-hand system and delivered to the passenger compartment. To simplify description and operation the distribution section is divided into two parts, the recirculating fan control system and the distribution system.


RAM AIR
HOT AIR
WARM AIR
COLD AIR
CONDITIONED AIR
PNEUMATIC AIR
CABIN COMPRESSOR
CABIN COMPRESSOR TURBINE SHUTOFF VALVE
HEAT EXCHANGER
HEAT EXCHANGER EXHAUST FLAP
CONDENSER FAN
REFRIGERANT CONDENSER AIR SELECTOR VALVE
RECIRCULATING CHECK VALVE
RECIRCULATING FAN
REFRIGERANT CONDENSER
CONDENSER EXHAUST FLAP
TEMPERATURE DIVERTER VALVE
WARM VALVE CHECK VALVE
REFRIGERANT TURBINE SHUTOFF VALVE
REFRIGERANT SURGE CONTROL EXPANSION VALVE
REFRIGERANT COMPRESSOR
REFRIGERANT FILTER DRIER
REFRIGERANT SURGE CONTROL MIXING TANK
REFRIGERANT RECEIVER DRIER
REFRIGERANT EVAPORATOR
REFRIGERANT EVAPORATOR EXPANSION VALVE
AIR CONDITIONING MIXING VALVE

AIR CONDITIONING SYSTEM SCHEMATIC

FTX80306

Figure 21-2



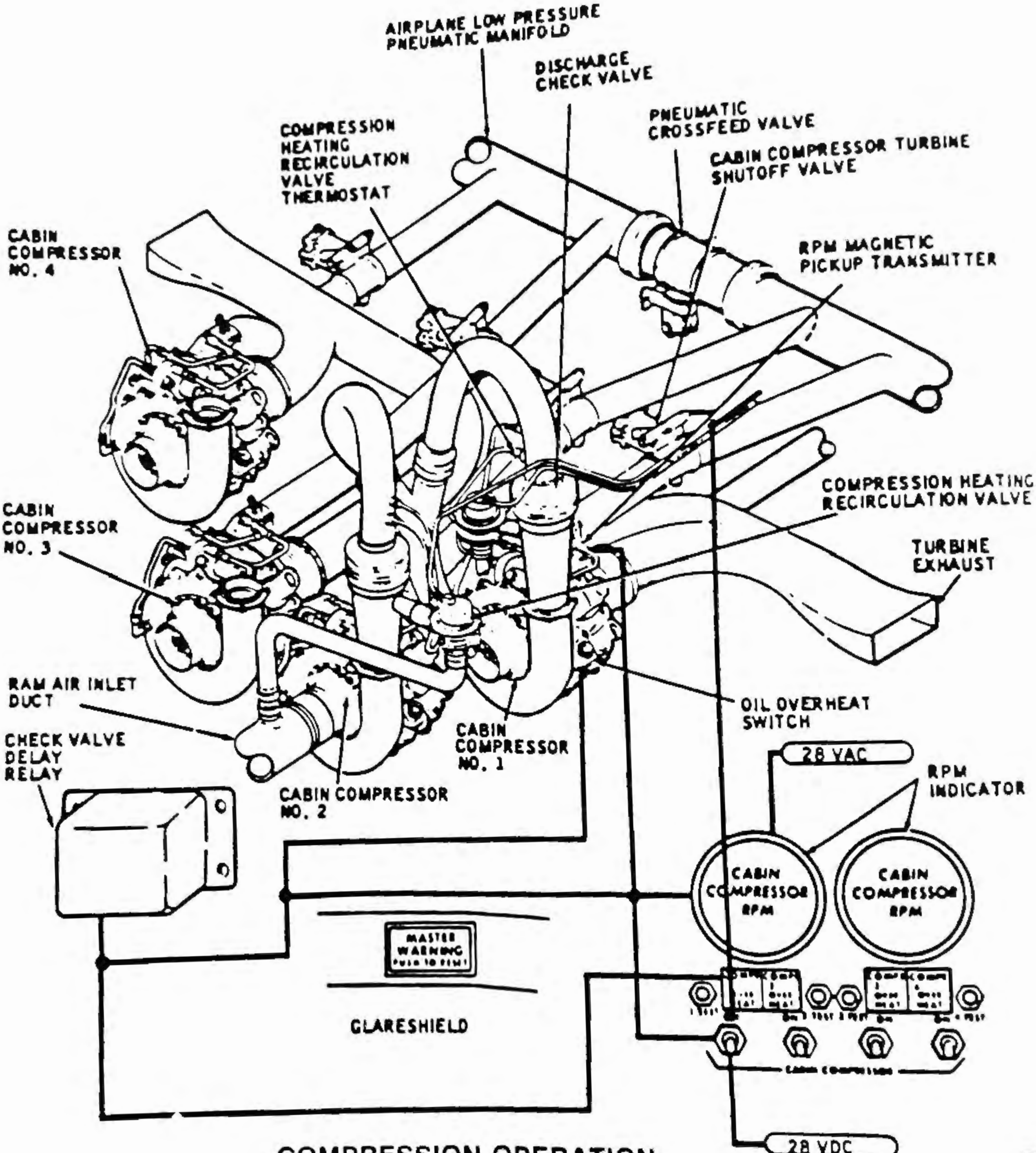
DC8 FWD FUSELAGE
BEFORE

ENVIRONMENTAL CONTROL UNIT INSTALLATION SUMMARY

SECTION A
AFTER

FTX80307

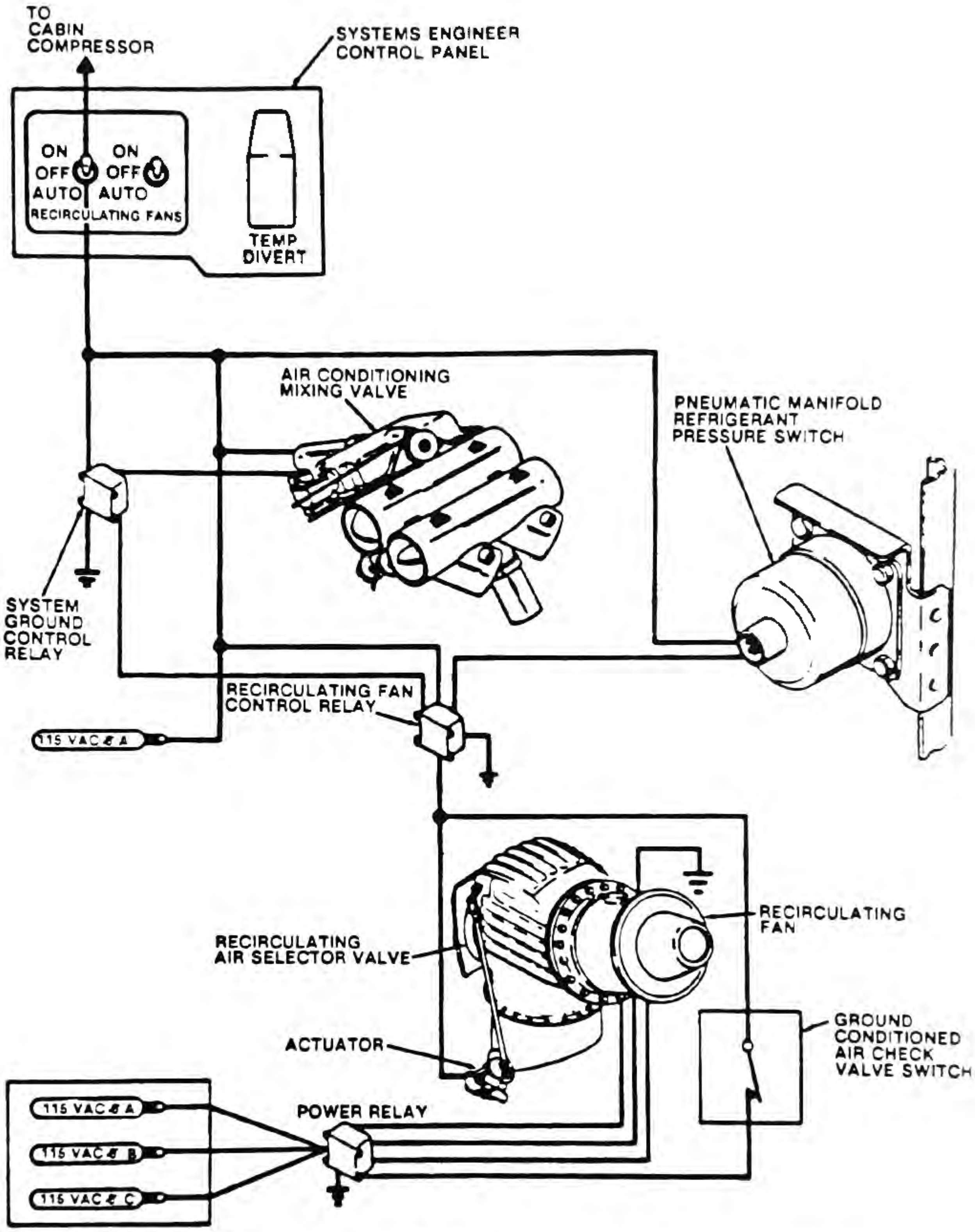
Figure 21-3



COMPRESSION OPERATION

FTX80308

Figure 21-4


TO CABIN COMPRESSOR
SYSTEMS ENGINEER CONTROL PANEL
ON
OFF
AUTO
ON
OFF
AUTO
RECIRCULATING FANS
TEMP DIVERT
AIR CONDITIONING MIXING VALVE
PNEUMATIC MANIFOLD REFRIGERANT PRESSURE SWITCH
SYSTEM GROUND CONTROL RELAY
RECIRCULATING FAN CONTROL RELAY
115 VAC Ɇ A
RECIRCULATING FAN
RECIRCULATING AIR SELECTOR VALVE
ACTUATOR
GROUND CONDITIONED AIR CHECK VALVE SWITCH
POWER RELAY
115 VAC Ɇ A
115 VAC Ɇ B
115 VAC Ɇ C

CABIN AIR RECIRCULATING FAN CONTROL OPERATION

FTX80309

Figure 21-5

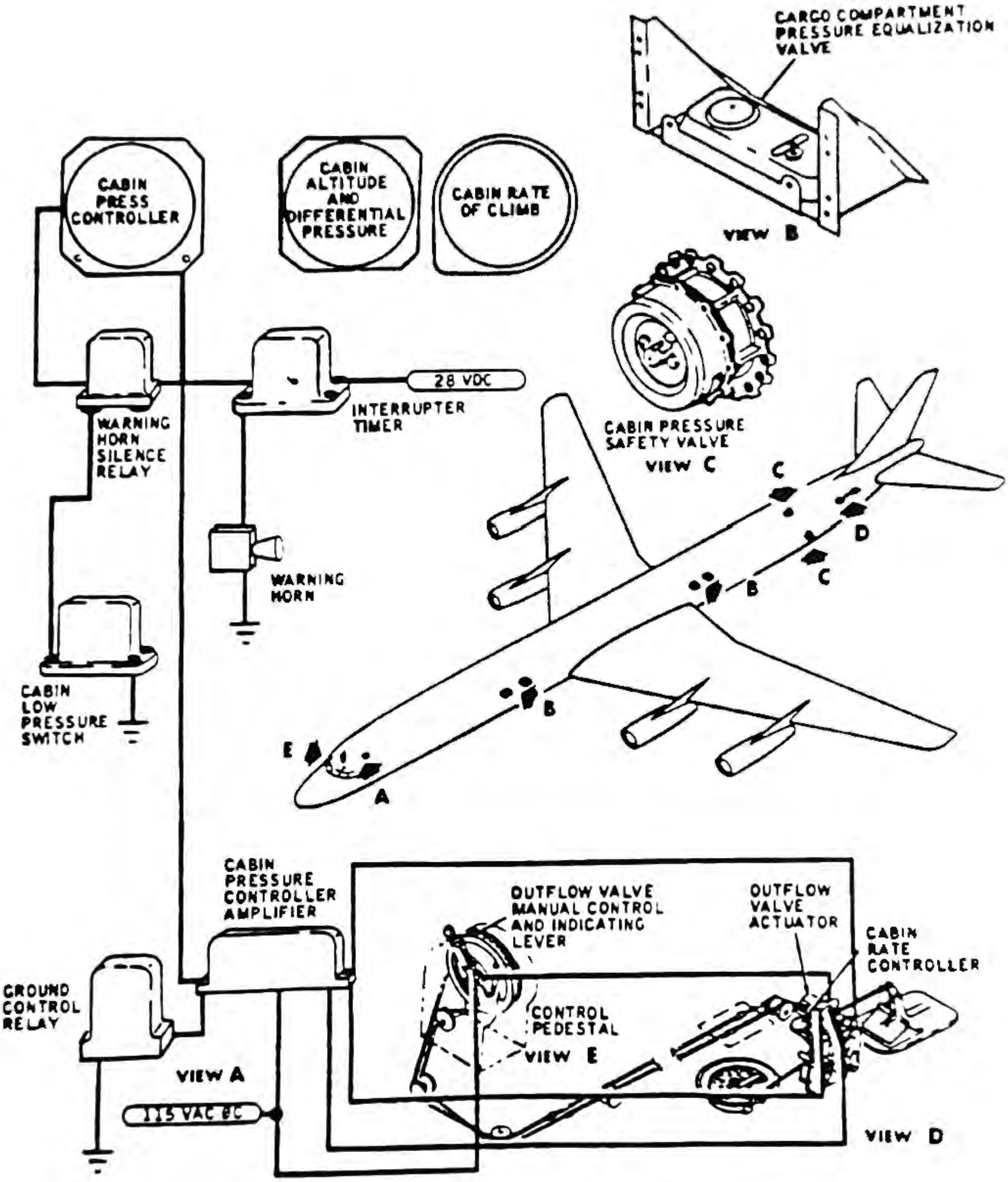
(b) Two recirculating fans provide air recirculation from the air conditioning accessory compartment or draws ventilating air through the nose wheel well to the distribution system. The fans operate continuously on the ground when the recirculating fan switch is in automatic position, except during backpressure heating. The fans are normally inoperative in flight, but when the fan switch is in on position and at least one cabin compressor switch on the applicable side is in off position, the fan operates to recirculate cabin air.

(c) Distribution system components consist of ducts, check valves, a temperature diverter valve, mufflers, and exhaust vents, which are necessary to direct and control air distribution throughout the airplane. Each component functions individually to perform a particular requirement within the distribution system.

(3) Pressurization Control

(a) The pressurization control system (Figure 21-6) is designed to maintain the pressurized areas of the airplane at a pressure altitude of sea level while the airplane is at an altitude of sea level to 23,000 feet, and at a pressure altitude of 6700 feet while the airplane is at an altitude of 40,000 feet. These pressures impose a normal cabin-to-atmosphere pressure differential up to 8.77 psi on the airplane structure. Pressurization is accomplished by discharging the output of the four cabin compressors into the passenger and flight compartments and limiting the amount of exhaust air by opening and closing the cabin air outflow valve.

(b) Normal operation is automatic after selecting the desired cabin altitude and cabin rate-of-change on the cabin pressure controller. Manual control is possible by physical operation of the cabin air outflow valve manual control and indicating lever. The pressurization control system is monitored by the cabin altitude and differential pressure indicator and the cabin rate-of-climb indicator. A cabin low pressure warning horn sounds intermittently when cabin pressure altitude exceeds approximately 10,000 feet. Two cabin pressure safety valves are set to relieve pressure if the pressure differential exceeds 8.82 psi.


CARGO COMPARTMENT PRESSURE EQUALIZATION VALVE
VIEW B
CABIN PRESS CONTROLLER
CABIN ALTITUDE AND DIFFERENTIAL PRESSURE
CABIN RATE OF CLIMB
28 VDC
INTERRUPTER TIMER
WARNING HORN SILENCE RELAY
CABIN PRESSURE SAFETY VALVE
VIEW C
WARNING HORN
CABIN LOW PRESSURE SWITCH
C
D
B
C
B
E
A
CABIN PRESSURE CONTROLLER AMPLIFIER
OUTFLOW VALVE MANUAL CONTROL AND INDICATING LEVER
OUTFLOW VALVE ACTUATOR
CABIN RATE CONTROLLER
CONTROL PEDESTAL
VIEW E
GROUND CONTROL RELAY
VIEW A
115 VAC BC
VIEW D

PRESSURIZATION CONTROL OPERATION

FTX80310

Figure 21-6

(4) Heating

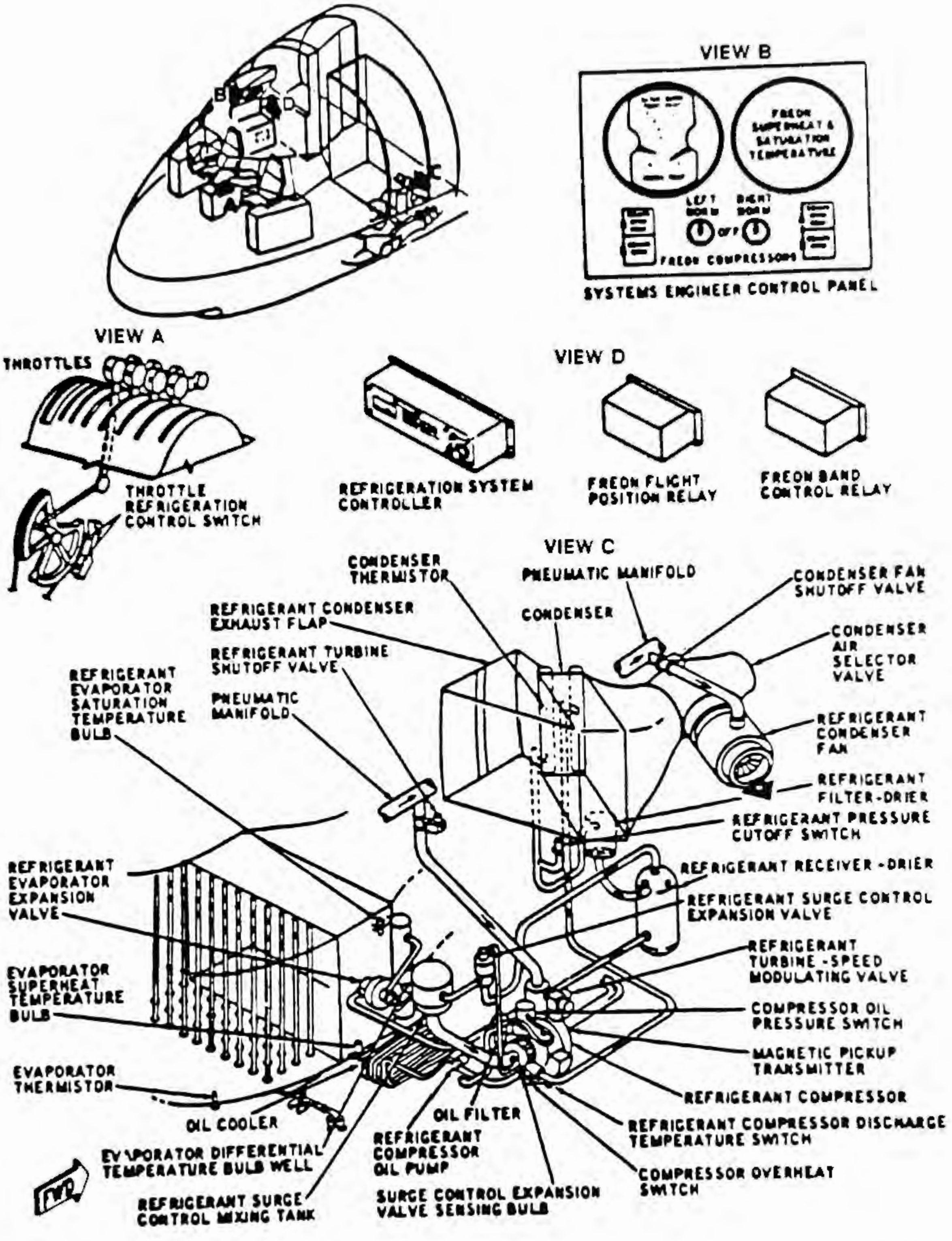
(a) Since the flight compartment floor is exposed to ambient conditions, electrically heated panels and fluted fiberglass panels provide the flight crew with foot warming facilities. Conditioned air is circulated through the fluted panels. Circuit breakers are the only controls provided for the electrical heating panels.

(b) There is also a supplemental heating system that provides heat while aircraft is on the ground. This system utilizes the left-hand conditioned air ducting by heating the air entering the flight compartment through the use of six heating elements mounted inside the heater assy which is spliced into the conditioned air ducting.

(5) Cooling

(a) The Douglas cooling system for the airplane is refrigeration control, refrigeration indication, radio rack control, and air conditioning heat exchanger control. The left refrigeration system (Figure 21-7), is provided to supplement air conditioning cooling in flight and give total cooling on the ground. Two distinct operational functions take place in each system. These are the mechanical function of the refrigeration cycle and the electrical function to stop, start, protect, and monitor system operation.

(b) Refrigerant 12 removes heat from the air by evaporation at low pressure, it is heated and compressed by the compressor, and then is circulated through the condenser where the heat is removed by cooling air. The refrigerant compressor is automatically operated to meet air conditioning system demands. Indicators are provided to monitor refrigerant compressor operation, oil overheat temperatures, and saturation and superheat temperatures in the refrigeration cycle.


B
D
A
C
VIEW B
FREON SUPERHEAT & SATURATION TEMPERATURE
LEFT
RIGHT
OFF
FREON COMPRESSORS
SYSTEMS ENGINEER CONTROL PANEL
VIEW A
THROTTLES
THROTTLE REFRIGERATION CONTROL SWITCH
REFRIGERATION SYSTEM CONTROLLER
VIEW D
FREON FLIGHT POSITION RELAY
FREON BAND CONTROL RELAY
VIEW C
CONDENSER THERMISTOR
PNEUMATIC MANIFOLD
CONDENSER FAN SHUTOFF VALVE
REFRIGERANT CONDENSER EXHAUST FLAP
CONDENSER
CONDENSER AIR SELECTOR VALVE
REFRIGERANT TURBINE SHUTOFF VALVE
REFRIGERANT EVAPORATOR SATURATION TEMPERATURE BULB
PNEUMATIC MANIFOLD
REFRIGERANT CONDENSER FAN
REFRIGERANT FILTER-DRIER
REFRIGERANT PRESSURE CUTOFF SWITCH
REFRIGERANT EVAPORATOR EXPANSION VALVE
REFRIGERANT RECEIVER-DRIER
REFRIGERANT SURGE CONTROL EXPANSION VALVE
REFRIGERANT TURBINE-SPEED MODULATING VALVE
EVAPORATOR SUPERHEAT TEMPERATURE BULB
COMPRESSOR OIL PRESSURE SWITCH
MAGNETIC PICKUP TRANSMITTER
EVAPORATOR THERMISTOR
REFRIGERANT COMPRESSOR
OIL COOLER
OIL FILTER
REFRIGERANT COMPRESSOR DISCHARGE TEMPERATURE SWITCH
EVAPORATOR DIFFERENTIAL TEMPERATURE BULB WELL
REFRIGERANT COMPRESSOR OIL PUMP
COMPRESSOR OVERHEAT SWITCH
FWD
REFRIGERANT SURGE CONTROL MIXING TANK
SURGE CONTROL EXPANSION VALVE SENSING BULB

REFRIGERATION SYSTEM

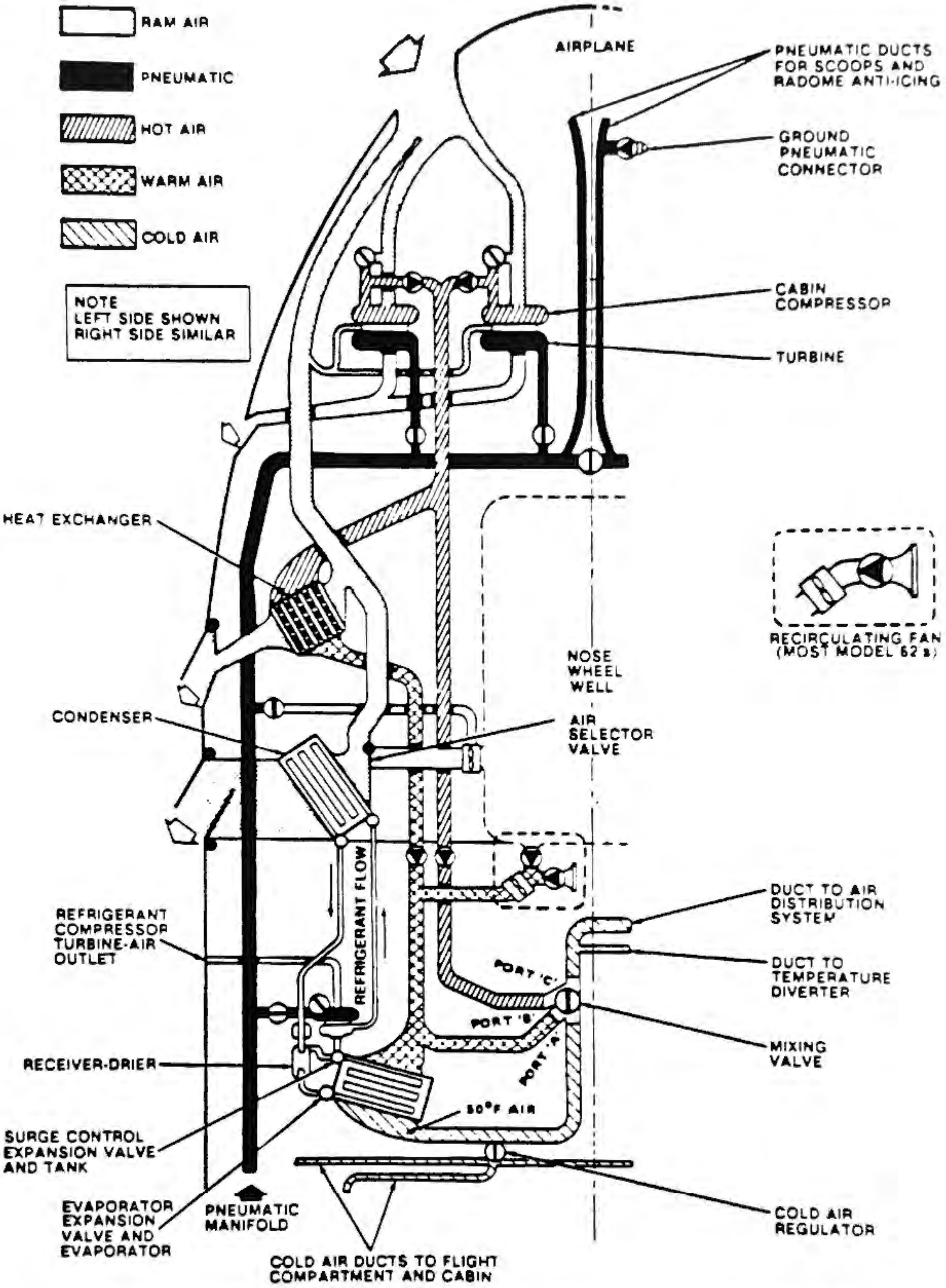
FTX80316

Figure 21-7

(c) Ram airflow across the air conditioning heat exchanger (Figure 21-8) is controlled by opening and closing the exhaust flaps with electrical actuators. The air conditioning heat exchanger amplifier controls the direction and degree of rotation of the exhaust flap actuator by controlling power to the actuator motor. The amplifier receives signals to increase or decrease airflow as demands for warmer or cooler air are made by the air conditioning mixing valve. A heat exchanger system is installed in the air conditioning system.

(d) The radio rack cooling system (Figure 21-9) controls and directs the flow of flight compartment exhaust air to ventilate and cool the electrical and electronic equipment, and heat the forward lower cargo compartment. The venturi, ducts, and baffled air passages, together with the radio rack blower and radio rack cooling valve, are arranged so that the necessary amount of cooling air is available for the installed equipment. Flow of exhaust air from the flight compartment prevents concentration of smoke in the flight compartment if equipment becomes overheated. The radio rack is shrouded and connected by ducts to the radio rack blower, which operates continuously when the airplane electrical buses are energized. After performing the radio rack cooling function the air is normally circulated between the forward cargo compartment floor and airplane insulation.

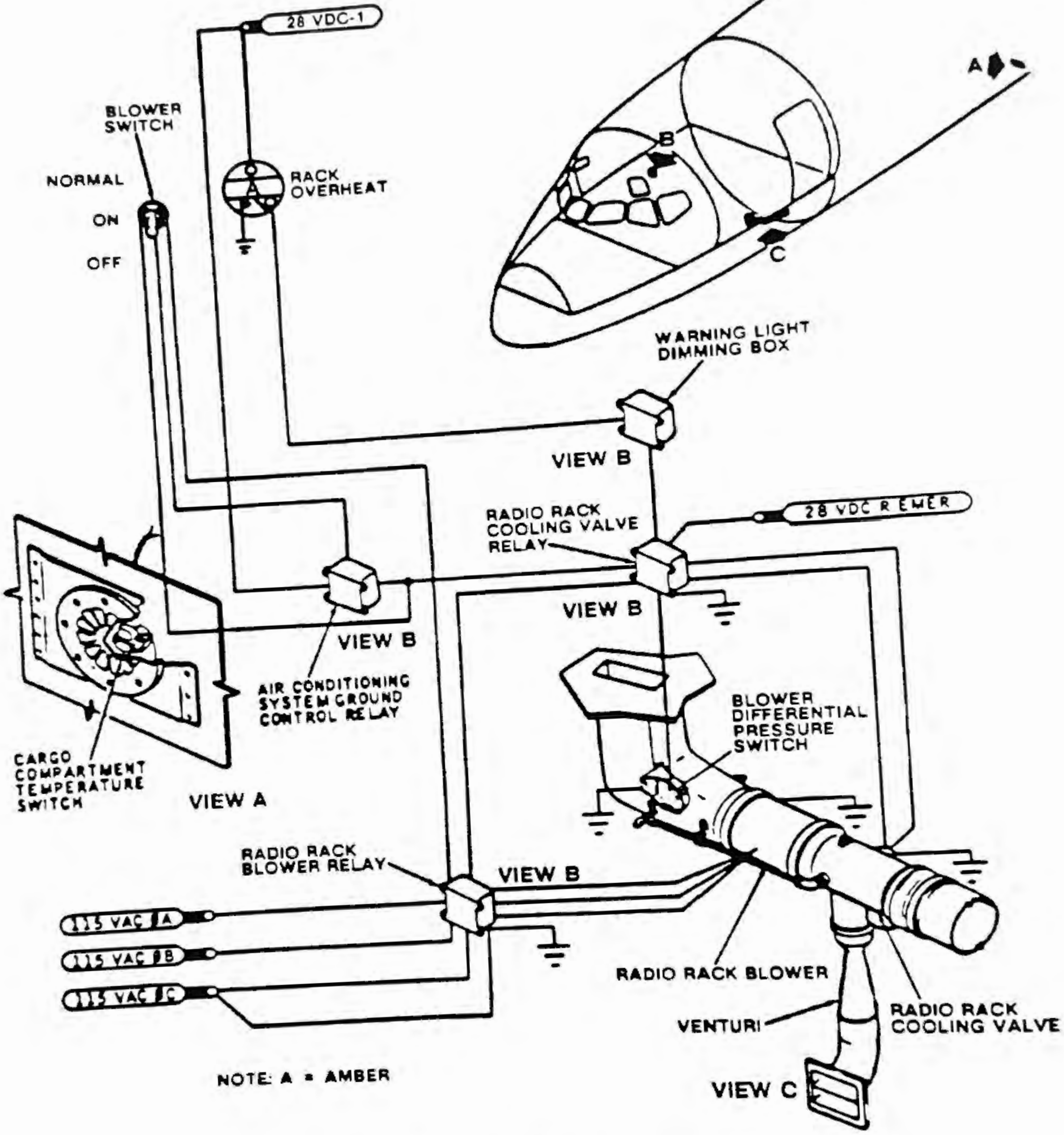
(e) The ABX supplemental refrigeration system is used to supplement flight compartment cooling. This system is used in lieu of the original Douglas right-hand refrigeration system, which is partially removed and deactivated. The system consists of a compressor/condenser module, two remotely located evaporator units, associated switches, and hoses. This system is independent of the aircraft left refrigeration system, and only supplies cool air to the cockpit (Figure 21-10).


RAM AIR
PNEUMATIC
HOT AIR
WARM AIR
COLD AIR
NOTE
LEFT SIDE SHOWN
RIGHT SIDE SIMILAR
AIRPLANE
PNEUMATIC DUCTS FOR SCOOPS AND RADOME ANTI-ICING
GROUND PNEUMATIC CONNECTOR
CABIN COMPRESSOR
TURBINE
HEAT EXCHANGER
RECIRCULATING FAN (MOST MODEL 62's)
NOSE WHEEL WELL
CONDENSER
AIR SELECTOR VALVE
REFRIGERANT FLOW
REFRIGERANT COMPRESSOR TURBINE-AIR OUTLET
DUCT TO AIR DISTRIBUTION SYSTEM
DUCT TO TEMPERATURE DIVERTER
PORT 'C'
PORT 'B'
PORT 'A'
MIXING VALVE
RECEIVER-DRIER
50°F AIR
SURGE CONTROL EXPANSION VALVE AND TANK
EVAPORATOR EXPANSION VALVE AND EVAPORATOR
PNEUMATIC MANIFOLD
COLD AIR DUCTS TO FLIGHT COMPARTMENT AND CABIN
COLD AIR REGULATOR

REFRIGERATION SYSTEM & RELATED A/C SYSTEM COMPONENTS

FTX80342

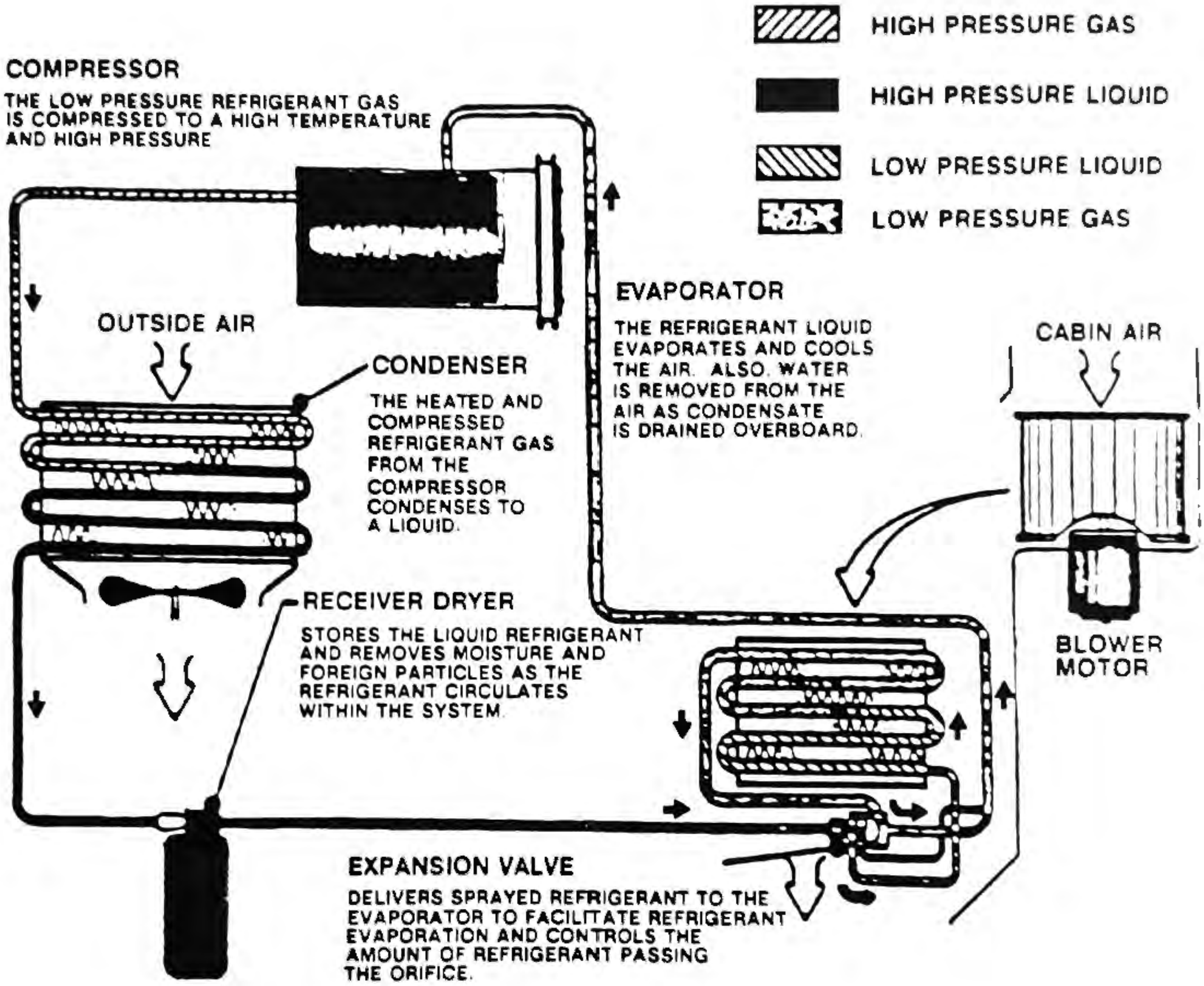
Figure 21-8



RADIO RACK COOLING OPERATION

FTX80314

Figure 21-9



COMPRESSOR
THE LOW PRESSURE REFRIGERANT GAS IS COMPRESSED TO A HIGH TEMPERATURE AND HIGH PRESSURE

CONDENSER
THE HEATED AND COMPRESSED REFRIGERANT GAS FROM THE COMPRESSOR CONDENSES TO A LIQUID.

EVAPORATOR
THE REFRIGERANT LIQUID EVAPORATES AND COOLS THE AIR. ALSO, WATER IS REMOVED FROM THE AIR AS CONDENSATE IS DRAINED OVERBOARD.

RECEIVER DRYER
STORES THE LIQUID REFRIGERANT AND REMOVES MOISTURE AND FOREIGN PARTICLES AS THE REFRIGERANT CIRCULATES WITHIN THE SYSTEM.

EXPANSION VALVE
DELIVERS SPRAYED REFRIGERANT TO THE EVAPORATOR TO FACILITATE REFRIGERANT EVAPORATION AND CONTROLS THE AMOUNT OF REFRIGERANT PASSING THE ORIFICE.

REFRIGERATION SYSTEM OPERATION

FTX80315

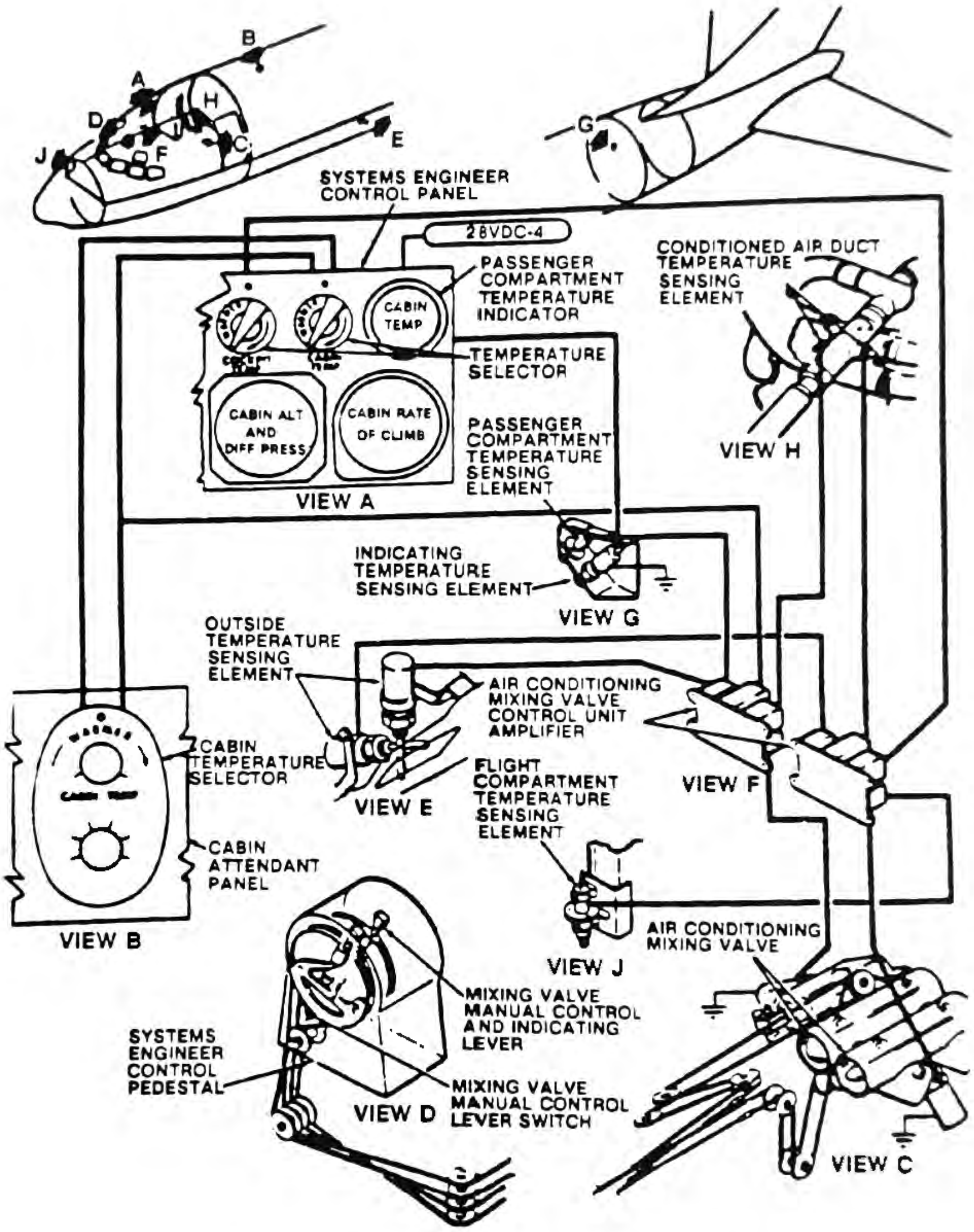
Figure 21-10

(f) The ABX supplemental refrigeration system compressor/condenser module consists of the following units: compressor assembly, motor assembly, coil assembly (condenser), and receiver/dryer assembly. The freon compressor is a 5 cylinder rotary piston type compressor with an anti-liquid as air, drawn from the nose wheel well by a fan mounted to the drive shaft, passes over the coils. The air that was used for cooling is then discharged overboard through a panel on the right side of the fuselage. The receiver dryer is used to store liquid refrigerant, and remove moisture and foreign particles as the refrigerant circulates within the system.

(g) The ABX supplemental refrigeration system has two identical evaporator units located in the cockpit, one forward and one aft. Each unit contains an evaporator with filter, blower motor, and fan, and an expansion valve. The blower motor is a 115 vac motor powered by the Supp Air Conditioning Cont circuit breaker. The high pressure liquid refrigerant is injected into the coil by the expansion valve. The expansion valve sprays refrigerant to the evaporator to facilitate refrigerant evaporation and controls the amount of refrigerant passing through the valve oriface. As the temperature of the refrigerant passing through the coils is much colder than the cabin air which is blown over the coils, heat from the cabin air is absorbed by the refrigerant, cooling the cabin air.

(6) Temperature control for the Douglas left-hand refrigeration system is done manually or automatically to maintain a selected temperature in the flight compartment. Three sources of air are connected to the three inlet parts of the air conditioning mixing valve. The temperature control system components position the mixing valve to flow the proper amount of hot, warm, and cold air as necessary to maintain the flight compartment at the desired temperature (Figure 21-11).

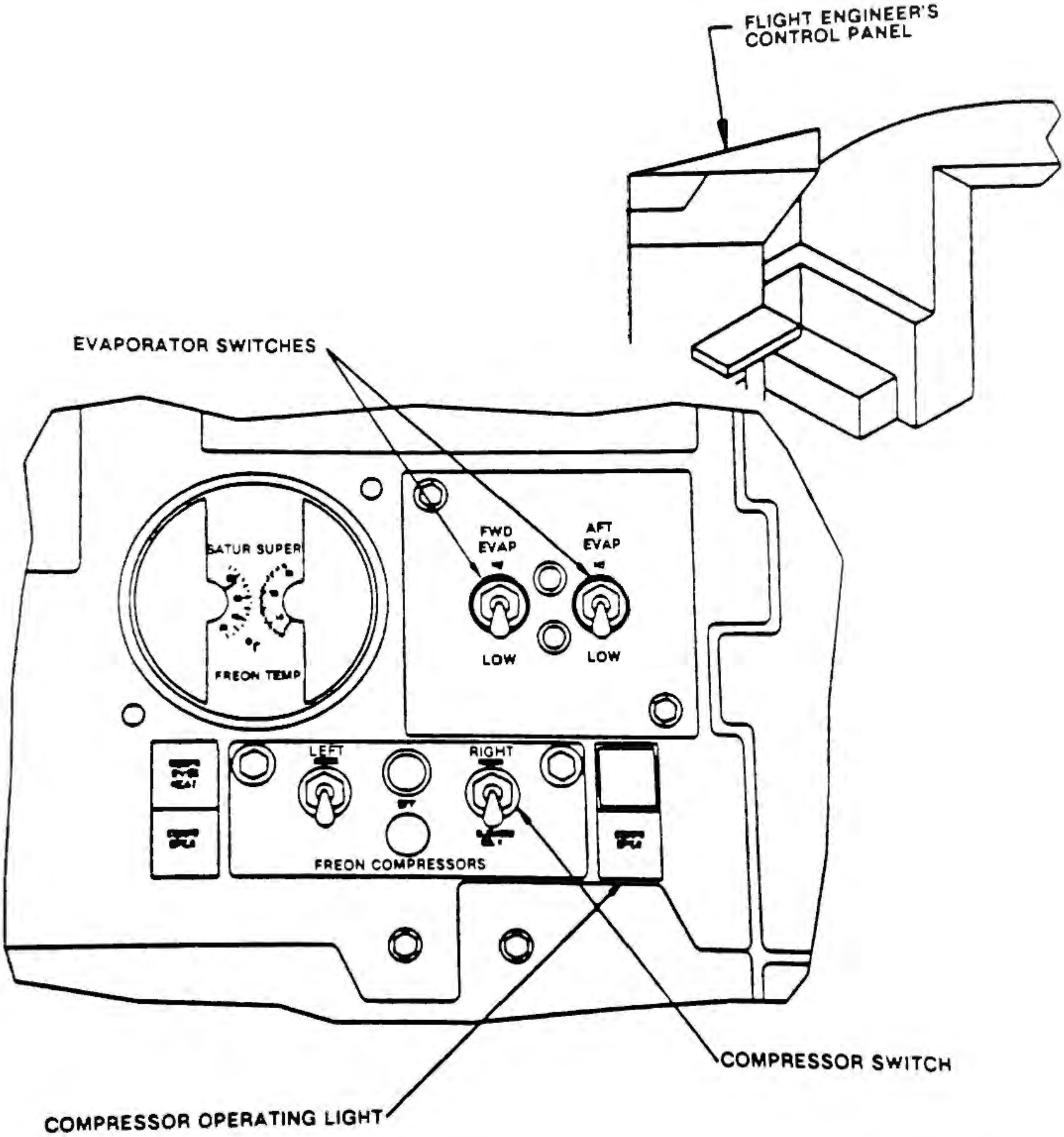
The ABX supplemental refrigeration system controls are located on the flight engineer's control panel, and are incorporated with the aircraft primary refrigeration system controls. The freon compressor control switch is installed in place of the original right freon comp switch. This is a three position switch: RIGHT NORM, BLOWER ONLY, and OFF. Also mounted on the control panel is a two position switch for each evaporator (fwd and aft) labeled HI and LOW (Figure 21-12).


B
A
H
D
J
F
C
E
G
SYSTEMS ENGINEER CONTROL PANEL
28VDC-4
PASSENGER COMPARTMENT TEMPERATURE INDICATOR
CABIN TEMP
TEMPERATURE SELECTOR
CABIN ALT AND DIFF PRESS
CABIN RATE OF CLIMB
PASSENGER COMPARTMENT TEMPERATURE SENSING ELEMENT
VIEW A
CONDITIONED AIR DUCT TEMPERATURE SENSING ELEMENT
VIEW H
INDICATING TEMPERATURE SENSING ELEMENT
VIEW G
OUTSIDE TEMPERATURE SENSING ELEMENT
AIR CONDITIONING MIXING VALVE CONTROL UNIT AMPLIFIER
WARMER
CABIN TEMP
CABIN TEMPERATURE SELECTOR
VIEW E
FLIGHT COMPARTMENT TEMPERATURE SENSING ELEMENT
VIEW F
CABIN ATTENDANT PANEL
VIEW B
VIEW J
AIR CONDITIONING MIXING VALVE
MIXING VALVE MANUAL CONTROL AND INDICATING LEVER
SYSTEMS ENGINEER CONTROL PEDESTAL
MIXING VALVE MANUAL CONTROL LEVER SWITCH
VIEW D
VIEW C

TEMPERATURE CONTROL OPERATION

FTX80318

Figure 21-11



ABX SUPPLEMENTAL REFRIGERATION SYSTEM CONTROLS

FTX80317

Figure 21-12

B. To Operate System

(1) General

(a) Power may be supplied to the Douglas refrigeration system from an external source or from an operating engine. Sufficient pneumatic and electrical power is available to operate the air conditioning system when the engines are operating at idle.

(b) The ABX supplemental refrigeration system is controlled from the air conditioning control panel at the flight engineer's position. When the freon compressor switch is in NORM position the freon compressor will supply liquid refrigerant to both evaporators; the evaporator motors will operate at the selected speed, hi or low, and the compressor operate light will illuminate. With the compressor switch placed in the blowers only position: the compressor will be off, and the evaporator motors will be operating at the speed selected by the respective evaporator blower switch.

(c) The amount of heating or cooling provided by the air conditioning system is dependent upon ambient temperatures and humidity. With an ambient temperature of 95°F dry bulb (FDB) and 78°F wet bulb (FWB), both refrigerant systems and all recirculating fans operating, and with an initial cabin temperature of 105° (40.6°C), the airplane can be cooled to 75° (23.9°C), in approximately 28 minutes. With air supplied from a ground cart at 312 pounds per minute and 450° (232.2°C) and with an initial cabin temperature of 105°F, the airplane can be cooled to 75°F in approximately 18 minutes.

(d) The air conditioning system is controlled and monitored from the flight engineer's control panel in the flight compartment.

(2) Ground Pneumatic Supply Requirements (Douglas system only)

(a) The temperature of the air supplied to the airplane pneumatic system directly affects the efficiency and service life of certain airplane system components. Ice formation in the discharge air from the turbine of an airplane refrigerant or cabin compressor affects performance and control, and causes erosion in the turbine.

Maintaining a minimum temperature of 160°F (71°C), at a pressure of 30 to 40 psig, at the fuselage nose ground pneumatic connector prevents ice formation.

(b) Oil entrained in the supply air picks up dirt; and, when in contact with hot machine parts, forms gum and hard deposits which affect friction and cause pressure drops in control orifices. At 160°F (71°C) oil is still in liquid form, but at 450°F (232°C) most of the oil remains vaporized throughout the cycle. Because even a 10-micron, entrapment-type filter cannot be depended upon to remove all the oil, centrifugal compressors, and reciprocating compressors with carbon piston rings, are preferred as ground pneumatic sources. All ground sources, except centrifugal compressors, must incorporate a 10-micron filter, and all ducting downstream of the filter must be maintained scrupulously free of rust and dirt particles. To reduce airflow requirements and to maintain residual oil in the entrained condition, the temperature of the supply air as delivered to the ground connector should be maintained at the highest value the airplane system involved can accept. Ground supply air can be applied to the ground connector at a maximum temperature of 460° (237°C) except when the deicing system is operating.

OPERATION	ELECTRIC POWER	PNEUMATIC POWER
Douglas air conditioning system.	40 kva at 115-volt, 3-phase, 400 cycle AC, and 28 vdc.	Flow -95 lb/min Pressure - 35 to 38 psig. Temperature - 350° to 450°F (176.7°) to 232.2°C)
ABX supplemental air conditioning system.	115 vac, 3-phase, 400 cycle AC.	None

CIRCUIT BREAKER	PANEL SECTION
Ground control relay	Miscellaneous (AC bus)
Cabin compressor shutoff and warning 1	Heat, vent, and ice protection (DC bus)
Cabin compressor shutoff and warning 2	Heat, vent, and ice protection (DC bus)
Cabin compressor shutoff and warning 3	Heat, vent, and ice protection (DC bus)
Cabin compressor shutoff and warning 4	Heat, vent, and ice protection (DC bus)
Cabin compressor valve control and rpm indicator 1	Instrument secondary
Cabin compressor valve control and rpm indicator 2	Instrument secondary
Cabin compressor valve control and rpm indicator 3	Instrument secondary
Cabin compressor valve control and rpm indicator 4	Instrument secondary
Left recirculating fan control	Heat, vent, and ice protection (AC bus)
Right recirculating fan control	Heat, vent, and ice protection (AC bus)
Cabin temperature indicator and diverter valve	Heat, vent, and ice protection (DC bus)
Aft cargo compartment blower phase A	Aft cabin electrical panel
Aft cargo compartment blower phase B	Aft cabin electrical panel
Aft cargo compartment blower phase C	Aft cabin electrical panel
Cabin pressure control	Heat, vent, and ice protection (AC bus)

CIRCUIT BREAKER	PANEL SECTION
Left cockpit floor heater	Heat, vent, and ice protection (AC bus)
Right cockpit floor heater	Heat, vent, and ice protection (AC bus)
Takeoff and cabin low pressure warning	Miscellaneous DC bus 1
Left freon power	Heat, vent, and ice protection (AC bus)
Right freon power	Heat, vent, and ice protection (AC bus)
Left freon control	Heat, vent, and ice protection (DC bus)
Right freon control	Heat, vent, and ice protection (DC bus)
Left freon compressor oil pump control	Heat, vent, and ice protection (DC bus)
Right freon compressor oil pump control	Heat, vent, and ice protection (DC bus)
Left freon compressor oil pump	Heat, vent, and ice protection (AC bus)
Right freon compressor oil pump	Heat, vent, and ice protection (AC bus)
Freon saturation and superheat temperature	Heat, vent, and ice protection (DC bus)
Freon compressor and overheat warning	Heat, vent, and ice protection (DC bus)
Radio rack blower phase A	Miscellaneous (AC bus)
Radio rack blower phase B	Miscellaneous (AC bus)
Radio rack blower phase C	Miscellaneous (AC bus)
Radio rack blower warning	Miscellaneous (DC bus 1)

CIRCUIT BREAKER	PANEL SECTION
Radio rack cooling	Right DC emergency bus
Left air condition heat exchanger	Heat, vent, and ice protection (AC bus)
Right air condition heat exchanger	Heat, vent, and ice protection (AC bus)
Air condition mix valve left	Heat, vent, and ice protection (AC bus)
Air condition mix valve right	Heat, vent, and ice protection (AC bus)
Systems engineer panel red light	Heat, vent, and ice protection (AC bus)
Compressor Operation (ABX Supplemental)	Heat, vent, and ice protection (AC bus)
Compressor Drive Motor (ABX Supplemental)	Radio Bus 3 (28 vdc)

CONTROL	FUNCTION
Cabin compressor switches 1, 2, 3 and 4	
On position	Open cabin compressor turbine shut-off valve to start compressor when low pressure air supply is available in pneumatic manifold
Off position	Close cabin compressor shutoff valve to stop compressor
Cabin compressor overspeed test switches 1, 2, 3 and 4	When pressed, check ability of cabin compressor overspeed circuit to stop compressor
Left recirculating fan switch	
Automatic position	Start left fan on ground to recirculate or ventilate cabin air.

CONTROL	FUNCTION
On position	Start fan in flight
Off position	Stop fan
Right recirculating fan switch	
Automatic position	Start right fan on ground to recirculate or ventilate cabin air
On position	Start fan in flight
Off position	Stop fan
Temperature diverter valve switch (guarded)	
Guarded position	Open temperature diverter valve
Unguarded position	Close temperature diverter valve
Cabin pressure controller	
Altitude selector knob (normal or retracted position)	Set desired cabin altitude in feet as indicated in window
Altitude selector know (pulled out position)	Set airport barometric pressure in inches of mercury or millibars
Rate control knob	Set desired cabin rate of climb in feet per minute
Cabin air outflow valve manual control and indicating lever	With know in normal position, lever indicates position of cabin air outflow valve in automatic mode. With know on lever lifted and turned 90 degrees, lever manually controls position of cabin air outflow valve
Altitude horn cutoff switch	Silence takeoff and cabin low pressure warning horn

CONTROL	FUNCTION
Freon compressor shutoff switches 1 and 2	
Normal position	Energize freon compressor starting circuits so that refrigeration cooling is available when demanded by air conditioning system
Off position	Deenergize freon compressor starting circuits
Radio rack blower switch	
Normal (guarded) position	Energize blower circuits and radio rack cooling valve close circuits when airplane is on ground; energize blower circuits and radio rack cooling valve circuits in flight when temperature of forward cargo compartment is between 60° and 75°F
Off position	Deenergize blower and energize radio rack cooling valve open circuits
On position	Energize blower and radio rack cooling valve close circuits
Cockpit temperature selector	Maintain temperature in flight compartment at temperature selected
abin temperature selector	Maintain temperature in passenger compartment at temperature selected
Air conditioning mixing valve manual control and indicating lever	With knob in normal position, lever indicates air conditioning mixing valve position while in automatic mode. With the lever lifted and turned 90 degrees, lever controls air conditioning mixing valve position

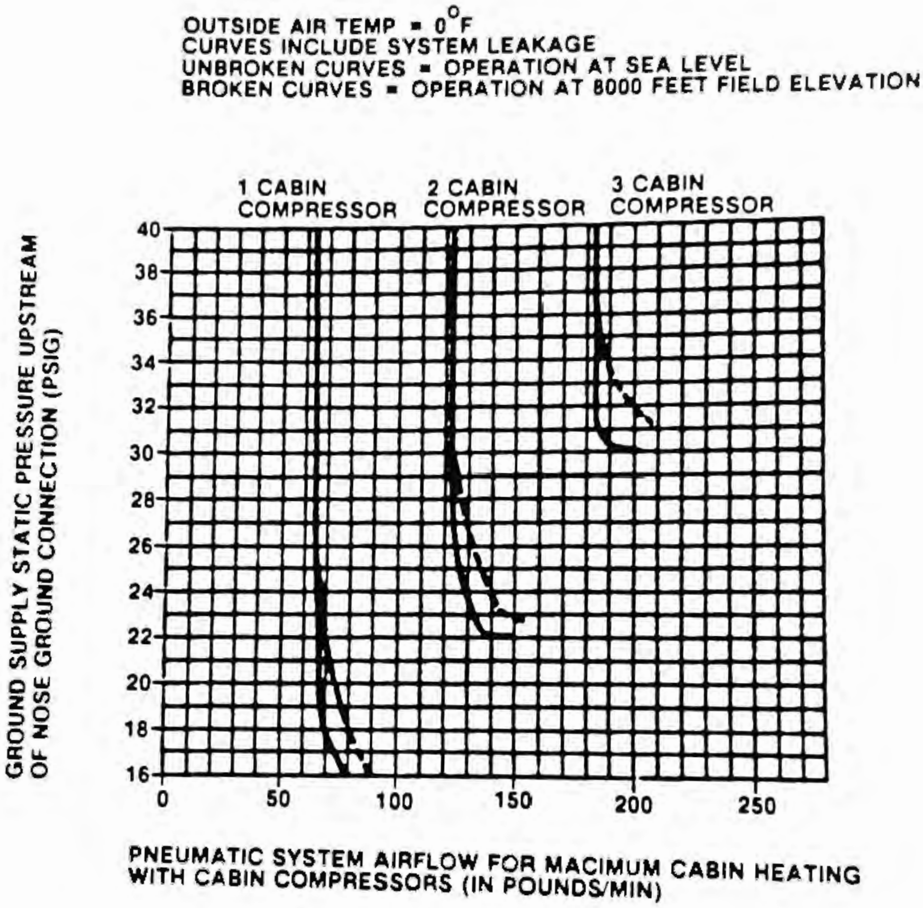
INDICATOR	FUNCTION
Cabin compressor rpm indicator	Indicate cabin compressor speed in rpm
Cabin compressor overheat indicator (red)	Indicates excessive oil temperatures in cabin compressor, or insufficient cabin compressor discharge differential pressure indicating a stall condition
Cabin altitude and differential pressure indicator	Indicate cabin altitude in feet and cabin-to-atmosphere differential pressure
Cabin rate-of-climb indicator	Indicate rate-of-climb of cabin altitude in feet per minute
Takeoff and cabin low pressure warning horn	Sound when airplane cabin altitude is approximately 9500 to 10,000 feet
Refrigerant compressor operating indicator (blue)	Indicator lights when refrigerant compressor is operating
Refrigerant compressor overheat indicator (amber)	Indicator lights amber when refrigerant compressor lubricating oil reaches excessive temperature
Refrigerant saturation and superheat temperature indicator	Indicate saturation temperature of refrigerant evaporator and superheat temperature at evaporator outlet
Radio rack overheat indicator	Indicator lights when less than 2 1/2 psi is sensed across radio rack blower duct and blower circuit is energized

(3) Pressure and Airflow Requirements (Figures 21-13 & 21-14)

(a) A ground pneumatic source cannot supply enough air to operate all four compressors at full back pressure heating, due to choking at the ground connection. When the manifold is pressurized from the engines, the engine power and the airplane pneumatic system automatically controls manifold temperature and pressure. When the manifold is pressurized from a ground pneumatic source that is applied to the fuselage nose ground pneumatic connector, the manifold pressure should be kept above 13 psig as indicated by the flight compartment manifold pressure indicator.

(b) The ground connector duct system chokes when the amount of air supplied to the system is sufficient to operate the four compressors at full back pressure. Four-compressor operation is possible on the ground at intermediate back pressures. The cabin compressors cannot operate at full back pressure below the lowest value shown in Figure 21-13. Airflow requirements are based on maximum steady-state demands of the airplane control systems. A ground pneumatic source with a capacity of 25 to 30 percent above the requirements shown in Figure 21-13, and 10 to 15 percent above the requirements shown in Figure 21-14, is to be used to avoid overbleeding during transient conditions. In considering the values of Figures 21-13 and 21-14, variations of as much as ±30°F in outside air temperature only slightly affect the pneumatic power requirements for a given air supply pressure and temperature.

(c) Normal manifold leakage permits the decay of airplane manifold pressure after the ground pneumatic source is shut off. Rapid relief of manifold pressure can be effected by operating any air-consuming airplane system except the refrigeration systems, provided the ground pneumatic source is first shut off.

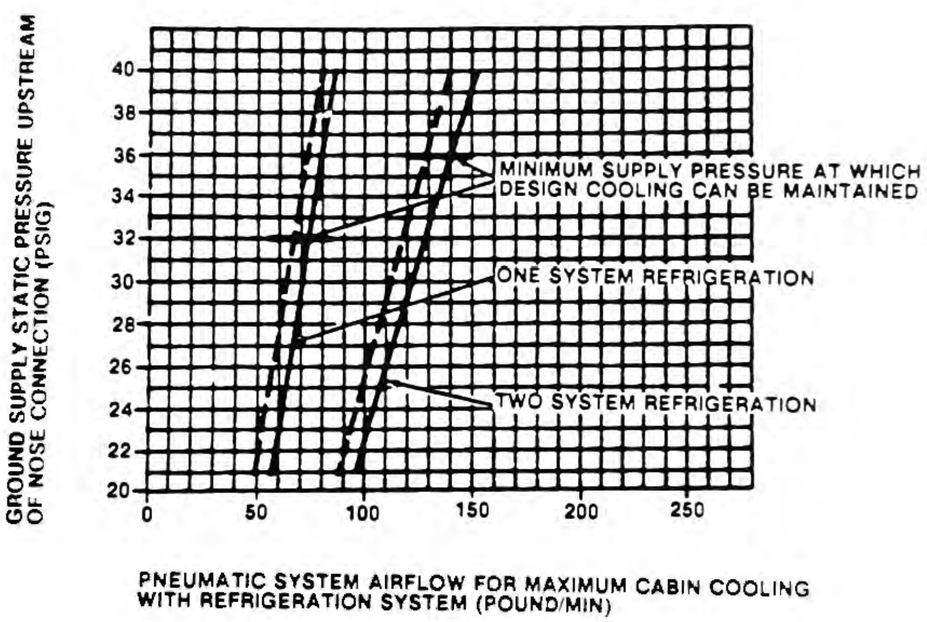


PNEUMATIC REQUIREMENTS FOR HEATING AIRPLANE

FTX80319

Figure 21-13

OUTSIDE TEMPERATURE - 95°F
CURVES INCLUDE SYSTEM LEAKAGE
UNBROKEN CURVE = OPERATION AT SEA LEVEL
BROKEN CURVES = OPERATION AT 8000 FT FIELD ELEVATION



PNEUMATIC REQUIREMENTS FOR COOLING AIRPLANE

FTX80320

Figure 21-14

(4) Start cabin compressor with Pneumatic pressure supplied from a ground source

CAUTION: **START COMPRESSORS ONE AT A TIME, A MINIMUM OF 15 SECONDS APART.**

(a) Position switches and controls as follows:

Control	**Position**
Freon compressor switches	Off
Cabin compressor switches	Off
Low pressure pneumatic manifold crossfeed valve switch	Down and guarded
Recirculating fan switches	Automatic
Temperature diverter valve switch	Down and guarded
Air conditioning mixing valve manual control and indicating lever	Automatic mode (unlocked position)
Cabin air outflow valve manual control and indicating lever	Automatic mode (unlocked position)
Engine throttles	Idle

NOTE: **The temperature control system is in automatic mode when the air conditioning mixing valve manual control and indicating lever knob is parallel with the control rack. The temperature control system is in manual mode when the manual control and indicating lever knob is extended and turned 90 degrees, allowing the lever to be locked in any position over the operating range. The cabin air outflow valve manual control and indicating lever functions similarly, to place the cabin pressurization system in automatic or manual mode.**

(b) Disconnect cabin compressor oil sump ram air duct, and connect cooling air source to compressor oil sump of each compressor to be started.

CAUTION: PERFORM STEP (2) FOR EXTENDED GROUND OPERATION OF CABIN COMPRESSORS. IF NO GROUND COOLING AIR IS SUPPLIED, CONTINUALLY MONITOR CABIN COMPRESSOR OVERHEAT WARNING LIGHT WHEN COMPRESSOR IS OPERATING. IF LIGHT COMES ON, IMMEDIATELY STOP COMPRESSOR. COMPRESSOR CAN BE RESTARTED WHEN LIGHT GOES OFF.

(c) Pressurize airplane pneumatic manifold.

(d) Check for minimum of 13 psig on pneumatic manifold air pressure indicator.

NOTE: The compressor overspeed test as given in steps (5) through (10) should be performed when starting each compressor except when the operator is certain that the compressor was previously operating satisfactorily, If the overspeed test is not performed, proceed to step (11).

(e) Place and lock applicable air conditioning mixing valve manual control and indicating lever in full decrease position.

(f) Place applicable cabin compressor switch in on position.

(g) Immediately press and hold corresponding test switch before compressor reaches 4000 rpm. check that cabin compressor rpm increases to between 5000 and 15,000 rpm, and then begins to drop to zero.

NOTE: To prevent erroneous results, test switch must be pressed and held before the compressor reaches 4000 rpm.

(h) Release test switch. Compressor should not start.

CAUTION: DO NOT OPERATE COMPRESSOR THAT FAILS OVERSPEED TEST UNTIL CAUSE OF MALFUNCTION IS DETERMINED.

(i) Place cabin compressor switch in off position. Allow at least 2 seconds before attempting to restart compressor.

(j) Place air conditioning mixing valve manual control and indicating lever in automatic mode.

(k) Place applicable cabin compressor switch in on position.

(l) Check that compressor speed stabilizes.

CAUTION: ADJACENT CABIN COMPRESSORS HUNTING SLOWLY IN PHASE, AS INDICATED BY OSCILLATIONS OF CABIN COMPRESSOR RPM INDICATORS, IS SOMETIMES CAUSED BY PRESSURE RATIO LIMITER, BUT PROLONGED SURGING OF COMPRESSOR MAY DAMAGE CHECK VALVES AND COMPRESSOR MUST BE STOPPED.

(5) Start cabin compressor with engines operating

(a) Position switches and controls as follows:

CONTROL	POSITION
Freon compressor switches	Off
Cabin compressor switches	Off
Low pressure pneumatic manifold crossfeed valve switch	Down and guarded
Recirculating fan switches	Automatic
Temperature diverter valve switch	Down and guarded
Air conditioning mixing valve manual control and indicating lever	Automatic mod (unlocked position)

Cabin air outflow valve manual control and indicating lever	Automatic mode (unlocked position)

NOTE: **The temperature control system is in automatic mode when the air conditioning mixing valve control and indicating lever knob is parallel with the control rack. The temperature control system is in manual mode when the manual control and indicating lever knob is extended and turned 90 degrees, allowing the lever to be locked in any position over the operating range. The cabin air outflow valve manual control and indicating lever functions similarly, to place the cabin pressurization system in automatic or manual mode.**

(b) Check for minimum of 13 psig on pneumatic manifold air pressure indicator.

NOTE: **The compressor overspeed test as given in steps (3) through (8) should be performed when starting each compressor except when the operator is certain that the compressor was previously operating satisfactorily. If overspeed test is not performed, proceed to step (9).**

(c) Place and lock applicable air conditioning mixing valve manual control and indicating lever in full decrease position.

(d) Place applicable cabin compressor switch in on position.

CAUTION: **OPERATING TIME OF CABIN COMPRESSORS IS LIMITED BY HEAT CAPACITY OF LUBRICATING OIL UNLESS AUXILIARY COOLING AIR IS SUPPLIED. IF NONE IS SUPPLIED, CONTINUALLY MONITOR CABIN COMPRESSOR OVERHEAT WARNING LIGHTS. IF LIGHT COMES ON, STOP COMPRESSOR AND ALLOW SUFFICIENT TIME FOR COMPRESSOR TO COOL BEFORE ESTARTING.**

(e) Immediately press and hold corresponding test switch before compressor reaches 4000 rpm. Check that cabin compressor rpm increases to between 5000 and 15,000 rpm, and then begins to drop to zero.

NOTE: To prevent erroneous results, test switch must be pressed and held before the compressor reaches 4000 rpm.

(f) Release test switch. Compressor should not start.

CAUTION: DO NOT OPERATE COMPRESSOR THAT FAILS OVERSPEED TEST UNTIL CAUSE OF MALFUNCTION IS DETERMINED.

(g) Place cabin compressor switch in off position. Allow at least 2 seconds before attempting to start compressor.

(h) Place air conditioning mixing valve manual control and indicating lever in automatic mode.

(i) Place applicable cabin compressor switch in on position.

(j) Check that compressor speed stabilizes.

CAUTION: ADJACENT CABIN COMPRESSORS HUNTING SLOWLY IN PHASE, AS INDICATED BY OSCILLATIONS OF CABIN COMPRESSOR RPM INDICATORS, IS SOMETIMES CAUSED BY PRESSURE RATIO LIMITER, BUT PROLONGED SURGING OF COMPRESSOR MAY DAMAGE CHECK VALVES AND COMPRESSOR MUST BE STOPPED.

(6) Start refrigeration system

(a) Position switches and controls as follows:

CONTROL	POSITION
Freon compressor switches	Off
Cabin compressor switches	Off
Recirculating fan switches	Automatic
Temperature diverter valve switch	Down and guarded
Air conditioning mixing valve manual control and indicating levers	Automatic mode (unlocked position)
Cabin air outflow valve manual control and indicating lever	Automatic mode (unlocked position)
Engine throttles	Idle

NOTE: The temperature control system is in automatic mode when the air conditioning mixing valve manual control and indicating lever knob is parallel with the control quadrant. The temperature control system is in manual mode when the manual control and indicating lever knob is extended and turned 90 degrees, allowing the lever to be locked in any position over the operating range. The cabin air outflow valve manual control and indicating lever functions similarly to place the cabin pressure control system in automatic or manual mode.

(b) Pressurize airplane pneumatic manifold.

(c) Place and lock applicable air conditioning mixing valve manual control and indicating lever in full decrease position.

(d) Place applicable freon compressor switch, located on systems engineer control panel, in normal position. Check that freon compressor operate (blue) light comes on after approximately 1 minute.

(e) After refrigerant compressor stabilizes, as observed on saturation temperature indicator, check following:

1 Saturation temperature is between 20° and 60°F (-7° and +16°C) as observed on saturation and superheat indicator on systems engineer control panel.

2 Superheat is between 0° and 20°F (0° and 11°C).

(7) Start air conditioning system

(a) Start applicable cabin compressors (see paragraph D or E).

NOTE: **Cabin compressors 1 and 2 supply air to the left air conditioning system, and cabin compressors 3 and 4 supply air to the right air conditioning system.**

(b) Place temperature selectors on systems engineer control panel in white dot position.

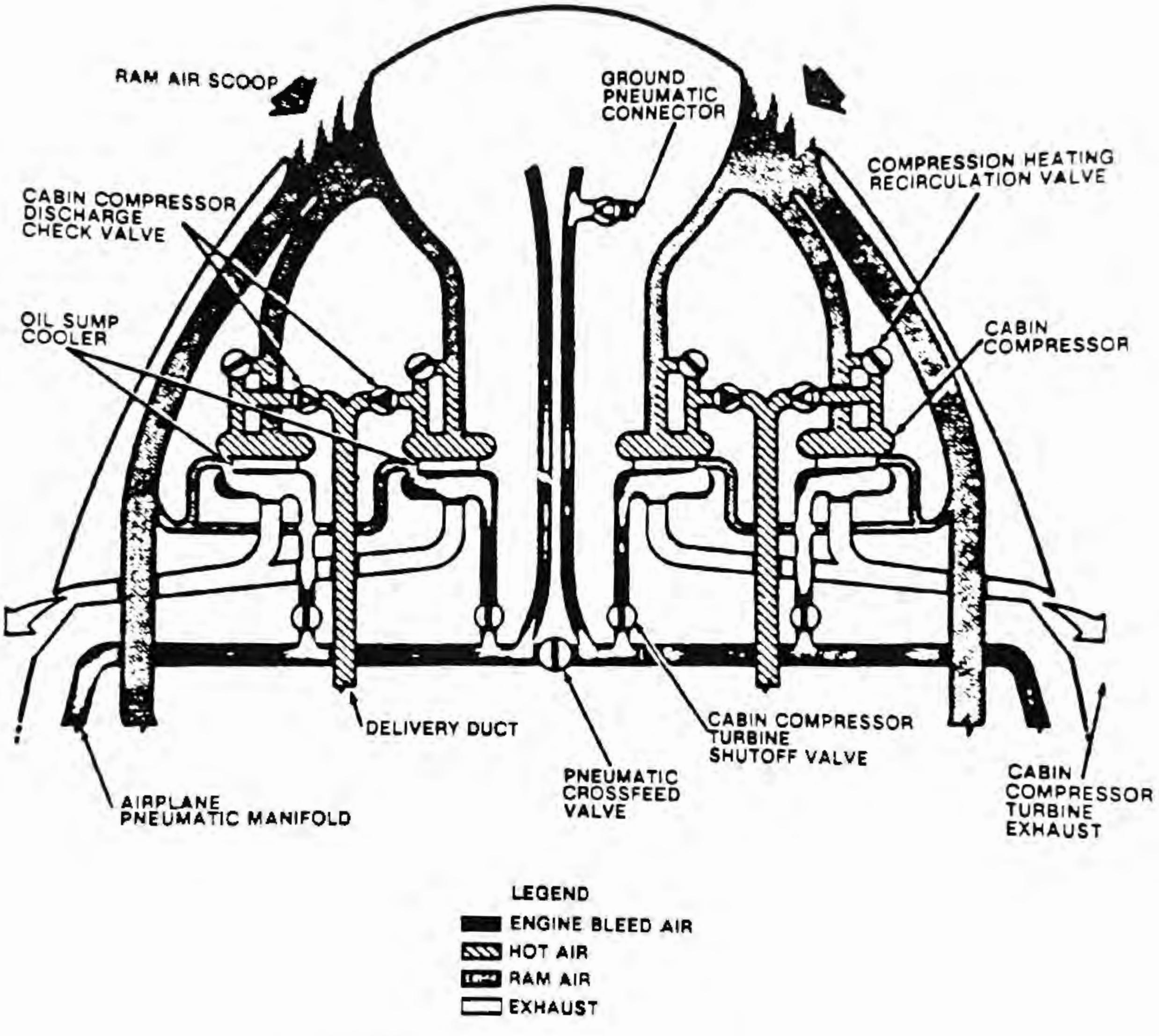
(c) Place applicable freon compressor switch in normal position.

NOTE: **Freon compressor operate (blue) light comes on only when the air conditioning system demands cold air from the refrigeration system and the refrigerant compressor is operating.**

2. Compression - Description and Operation

A. General

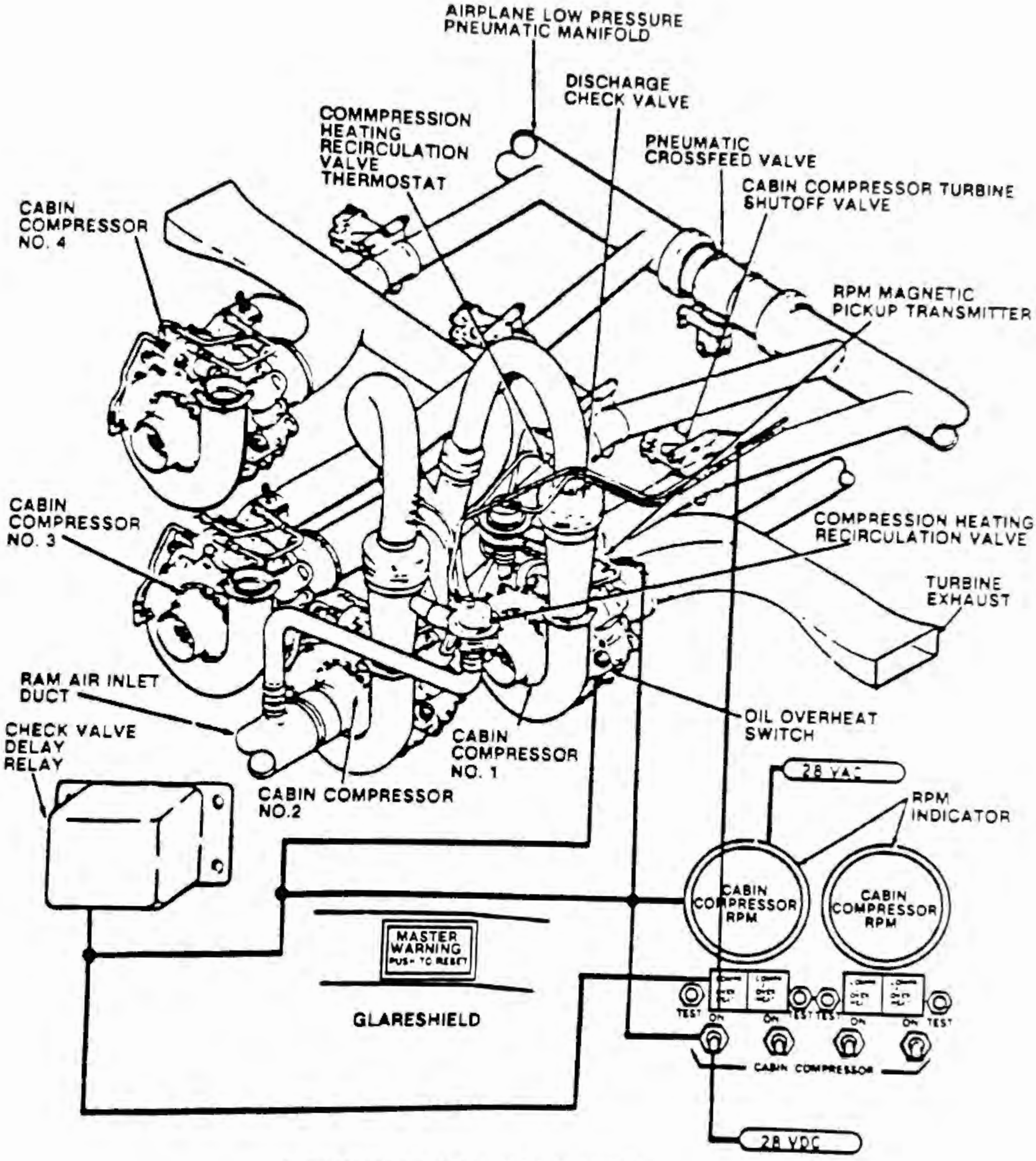
Fresh air supply for cabin pressurization and air conditioning is supplied by four cabin compressors located in the fuselage nose section. All four units are the same size and capacity. The two compressors on the left side of the fuselage centerline normally supply air for the flight compartment air conditioning system, and the two on the right normally supply the passenger compartment air conditioning system. Each compressor has a flow-measuring venturi, a rate control valve, and a turbine nozzle actuator which control compressor rpm by adjusting the pneumatic supply to the turbine section of the compressor. An electrical overspeed shutoff circuit is used to protect the compressors against overspeed conditions. Outside air for the compressors enters through ram air scoops located in the fuselage nose section (Figure 21-15). After passing through the compressors, the air can be further heated or cooled, as necessary, before distribution to the occupied areas of the fuselage. Lubrication for the bearing assembly of each compressor is supplied from an oil sump on the bottom of the compressor. The oil is cooled by routing air from the ram air scoops through cooling coils which are an integral part of the oil sump. Compressor overheat warning lights and rpm indicators are located on the systems engineer's control panel in the flight compartment. The overheat warning light comes on when excessive oil temperatures are sensed, or when abnormal pressure differential exists across the compressor return. Cabin compressor operation is controlled by switches located on the systems engineer's control panel (Figure 21-16). The switches actuate solenoid-controlled, pneumatically operated, turbine shutoff valves installed in the low-pressure pneumatic supply ducts.


RAM AIR SCOOP
GROUND PNEUMATIC CONNECTOR
COMPRESSION HEATING RECIRCULATION VALVE
CABIN COMPRESSOR DISCHARGE CHECK VALVE
OIL SUMP COOLER
CABIN COMPRESSOR
DELIVERY DUCT
CABIN COMPRESSOR TURBINE SHUTOFF VALVE
PNEUMATIC CROSSFEED VALVE
AIRPLANE PNEUMATIC MANIFOLD
CABIN COMPRESSOR TURBINE EXHAUST
LEGEND
ENGINE BLEED AIR
HOT AIR
RAM AIR
EXHAUST

COMPRESSION MECHANICAL SCHEMATIC

FTX80322

Figure 21-15



COMPRESSION OPERATION

FTX80321

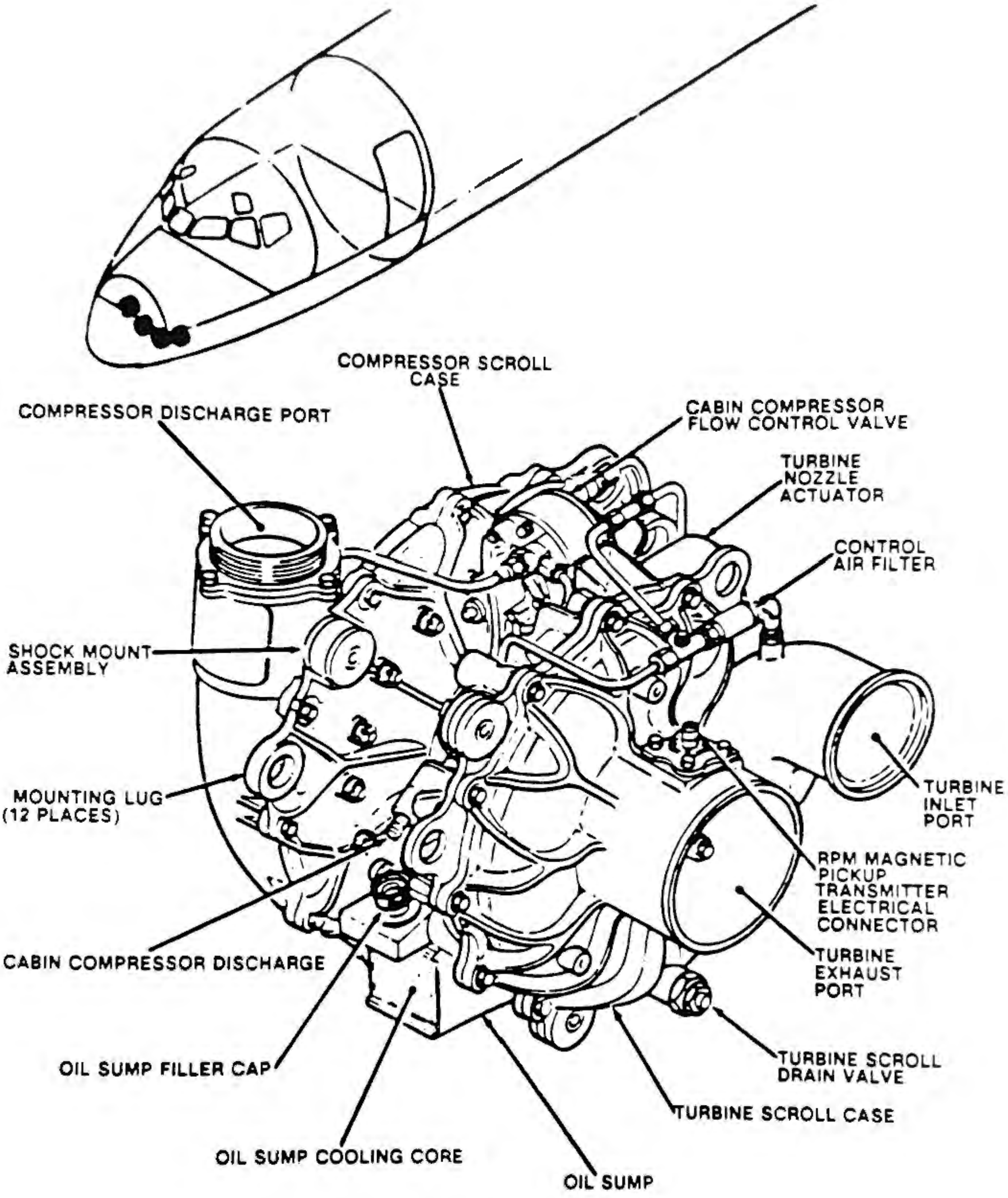
Figure 21-16

B. Component Description (Figures 21-17 & 21-18)

(1) Cabin Compressor

(a) There are four compressors installed in the nose equipment compartment to supply fresh air required for air conditioning and pressurization. The compressors are arranged in pairs on both sides of the airplane centerline, one pair for each air conditioning system. Each unit consists of a pneumatic turbine connected to a centrifugal compressor by a common shaft and bearing package. A tank-type oil sump is attached to the bottom of the bearing package housing. The compressor and turbine impeller shafts are pressed into the bearing package shaft and a long bolt through the center of the shafts ties all the rotating parts together. The rotating assembly is supported by two high-speed, angular-contact ball bearings pressed onto journals on the bearing package shaft. The bearing package shaft incorporates left and right spiral lands leading from the center outward in both directions. A close fitting sleeve covers the spiral area of the shaft to form an oil pump. This area, which is connected to the oil sump by a supply tube, is partially evacuated of air by the spiral lands as the shaft rotates within the sleeve. As a result, the reduced pressure in the spiral area causes oil from the sump to rise in the supply tube and the spiral lands to carry the oil across the shaft to each bearing. As the oil passes through the bearings, it is thrown outward by slinger rings and returns to the sump. Seals are mounted at each end of the bearing packages, to prevent the entry of oil or fumes into the compressor or turbine scrolls.

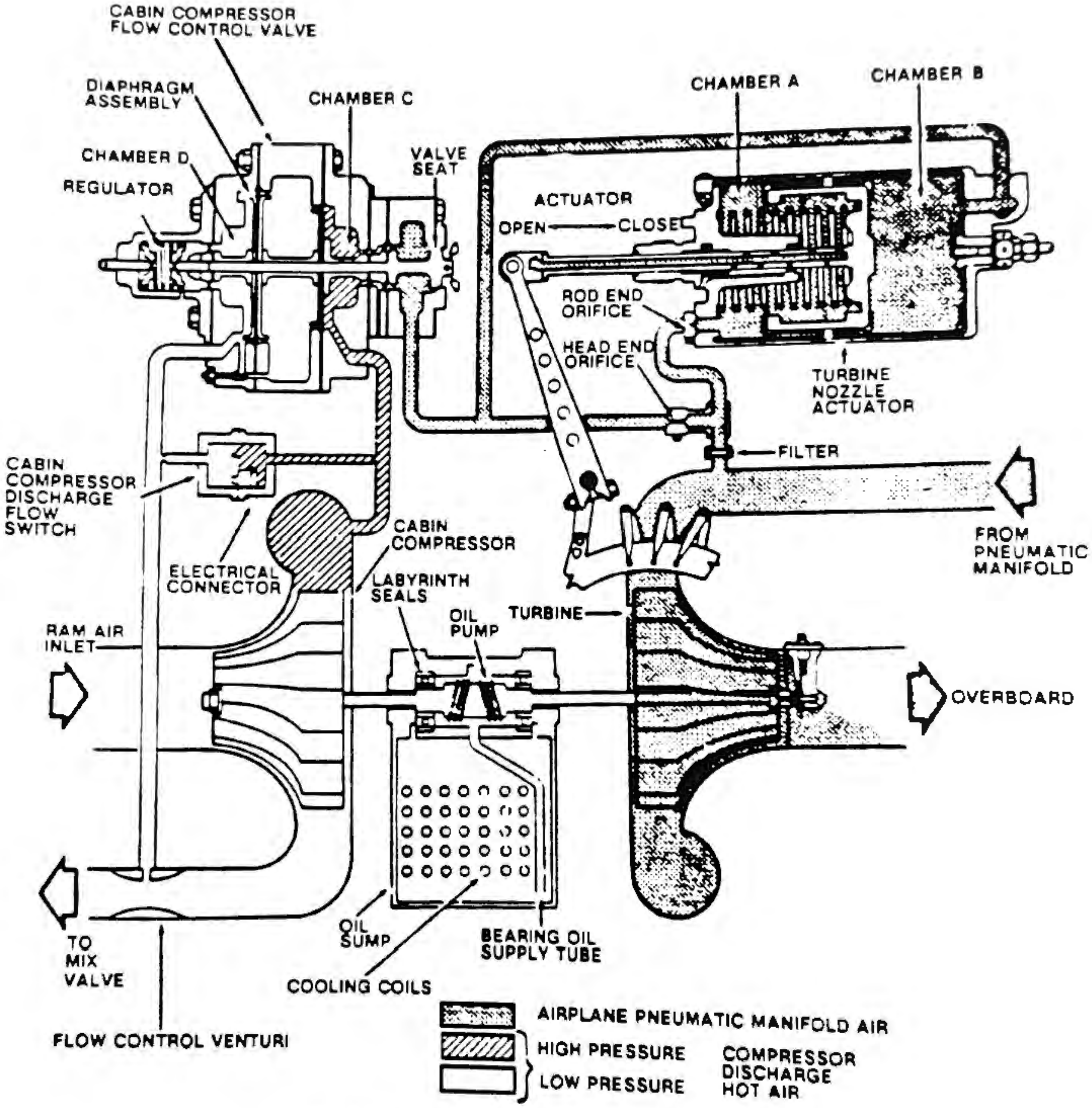
(b) The oil sump contains cooling coils through which ram air is ducted in flight. Ground operation of the compressor is limited by the heat capacity of the oil. The drain plug incorporates a magnetic plug and a check valve which prevents loss of oil when the magnetic plug is removed for inspection (Figure 21-19).



CABIN COMPRESSOR EXTERNAL VIEW

FTX80323

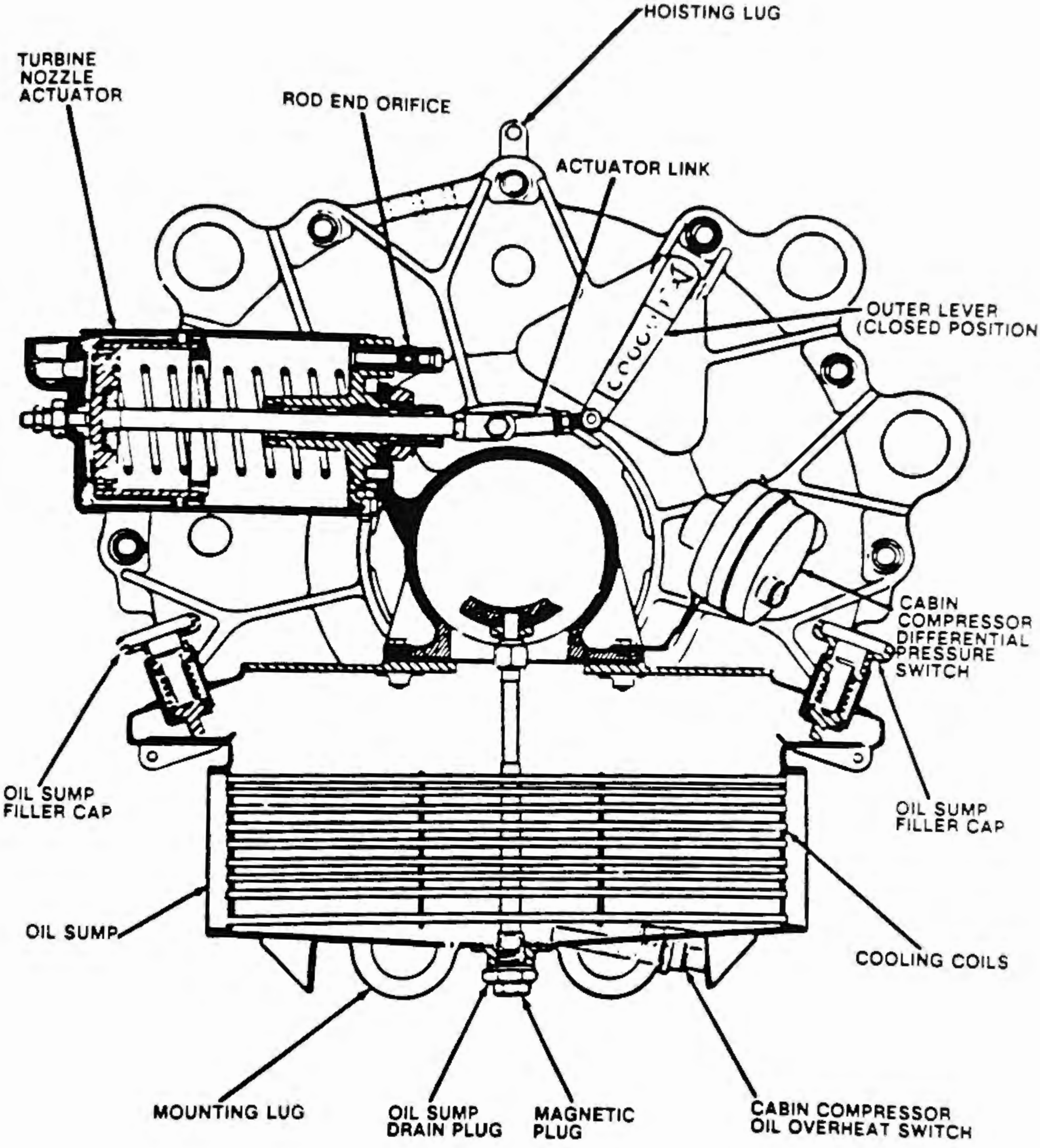
Figure 21-17



CABIN COMPRESSOR SCHEMATIC

FTX80324

Figure 21-18



CABIN COMPRESSOR SECTIONAL VIEW

FTX80325

Figure 21-19

(c) Changes in altitude, flight speed, outside air temperature, pneumatic manifold pressure and temperature, and compressor back pressure (cabin pressure), cause variations in compressor power requirements which must be compensated for by controlling the turbine power output. This is accomplished by controlling the flow area of the turbine nozzles. The 25 airfoil-shaped, variable nozzles are attached to a movable ring at one end and to a follower in a cam slot at the other end. The movable ring is connected by linkage to the actuating piston of the turbine nozzle actuator. Rotation of the ring causes the nozzles to open or close. Air pressure is diverted from the turbine inlet through a 10-micron filter to both ends of the actuator cylinder (Figure 21-18). Movement of the actuator piston is effected by bleeding varying amounts of air from each end, thus determining the differential pressure across the piston. Chamber A pressure is controlled by a series of bleed holes located in the hollow wall of the piston rod, adjacent to the piston head. As the piston moves to open the nozzles, the piston rod slides through a closely fitted bushing and progressively closes off the bleed holes to increase the pressure. This increasing opposition to further movement is augmented by a spring in the rod end of the actuator cylinder.

(d) Chamber D of the flow control valve is connected to the throat of the compressor venturi, and Chamber C is connected to the compressor scroll case. Airflow through the compressor creates a low pressure in the venturi throat and, consequently, a differential pressure across the flow control valve diaphragm. The diaphragm assembly moves the valve seat to bleed off Chamber B pressure. Since Chamber B pressure is controlled by the flow control valve, the opposing forces in the actuator balance and the turbine nozzles assume a stationary position. As discharge airflow varies, the flow control valve opens or closes to alter the pressure differential in the actuator which repositions the nozzles.

(e) Compressor overspeed protection is provided by the cabin compressor rpm magnetic pickup transmitter. The transmitter consists of four cylindrical, equally spaced coils, enclosed in a case which is located in a strut mounted in the turbine exhaust. Each coil consists of a wire-wound, permanent magnet. The four coils are connected in series. The transmitter is positioned in proximity to the balance assembly carrier, and the carrier bolt head has four equally spaced projections. Passage of each projection past the magnets of the transmitter generates a complete sine wave voltage cycle, which is applied as the input signal to the rpm indicator. At a temperature of 77°F (25°C), 28 volts excitation, and when compressor speed reaches 50,000 (±1000) rpm, a closing signal, is sent to the turbine shutoff valve. These tolerances are the result of variations in temperature and supply voltage. Tolerances within the indicator circuit can cause the indicated speed to vary from actual speed by ±1800 rpm. This tolerance, plus the overspeed tolerance, can result in overspeed cutout occurring up to an indicated 52,800 rpm.

(2) Cabin Compressor RPM Indicator

There are two dual indicating cabin compressor rpm indicators located side by side on the system engineer's control panel. Each indicator consists of two separate control and indication sections; each section functions with a single cabin compressor. The indicator contains rpm indication circuits and overspeed control circuits. The rpm indicating circuit amplifies and converts the sine wave input from the rpm magnetic pickup transmitter to a square wave signal, which is rectified to direct current. This current is applied to the meter movement of the indicator. The average current value applied to the meter movement is directly proportional to the frequency of the input signal from the transmitter. The overspeed circuit within the indicator consists of a high-pass filter, an amplifier, and a relay. The filter is connected to the square wave output of the indicator circuit. When compressor speed reaches 50,000 (±1000) rpm, the high-pass filter passes sufficient current to actuate the overspeed relay which controls power to the cabin compressor turbine shutoff valve.

(3) Cabin Compressor Discharge Differential Pressure Switch

A discharge differential pressure switch is mounted on each cabin compressor and is pneumatically connected across the compressor venturi (Figure 21-18). Since a decrease in airflow produces a decrease in pressure differential across the venturi, the switch senses the abnormal reduction in compressor discharge airflow. When pressure differential is being reduced, the switch contacts close at a differential pressure of 10.5 (±1.5) inches of water at 70°F (25°C). During increasing pressure differentials, the contacts open when differential pressure reaches approximately 20 inches of water at 70°F (25°C). The pressure switch, in conjunction with a delay relay, functions to

C. System Operation

(1) The four cabin compressor switches, located on the systems engineer's control panel, control power to the open and close solenoids of the cabin compressor turbine shutoff valves, in conjunction with the corresponding overspeed relays in the two cabin compressor rpm indicators. Each switch performs a similar function with one-half section of an rpm indicator. The simplified schematic shown in Figure 21-22 includes only one component of each cabin compressor control circuitry. The latching-type solenoids of the cabin compressor turbine shutoff valve remain in the last position selected so that if electrical power is not available, in-flight cabin pressurization can be maintained. Care should be taken to ensure that compressor switches are in the off position before disconnecting airplane electrical power on the ground. A set of contacts on each cabin compressor switch (not shown in Figure 21-22), prevents the engine starting circuit from being energized when any cabin compressor switch or freon compressor switch is in the on position.

(2) With the cabin compressor switch in off position, switch contacts B1 and B2 are closed and 28-vdc is applied to the close solenoid of the cabin compressor turbine shutoff valve. When low-pressure air is available to the pneumatic manifold, the valve is closed pneumatically. A 28-vac power source is available to the cabin compressor rpm indicator when the compressor valve control and rpm indicator circuit breaker is closed. When the airplane is on the ground and the applicable recirculation fan switch is in the automatic position, the cabin compressor cannot be started because the recirculating fan control relay is energized, and contacts C2 and C3 are closed to disarm the cabin compressor turbine shutoff valve open solenoid circuit. Under all other circumstances the cabin compressor starts when the cabin compressor switch is in the on position. Fan control relay contacts C1 and C2 are closed to arm the turbine shutoff valve open solenoid circuit from the 28-vdc output contacts of the overspeed relay. Contacts D2 and D3 also close to saturate the magnetic amplifier with 28-vac and to energize the overspeed relay. The relay contacts close to direct 28-vdc from the magnetic amplifier to the open solenoid of the turbine shutoff valve, thus starting the compressor.

energize the compressor overheat warning light, if the cabin compressor fails to produce the required pressure differential for a continuous 15-second period.

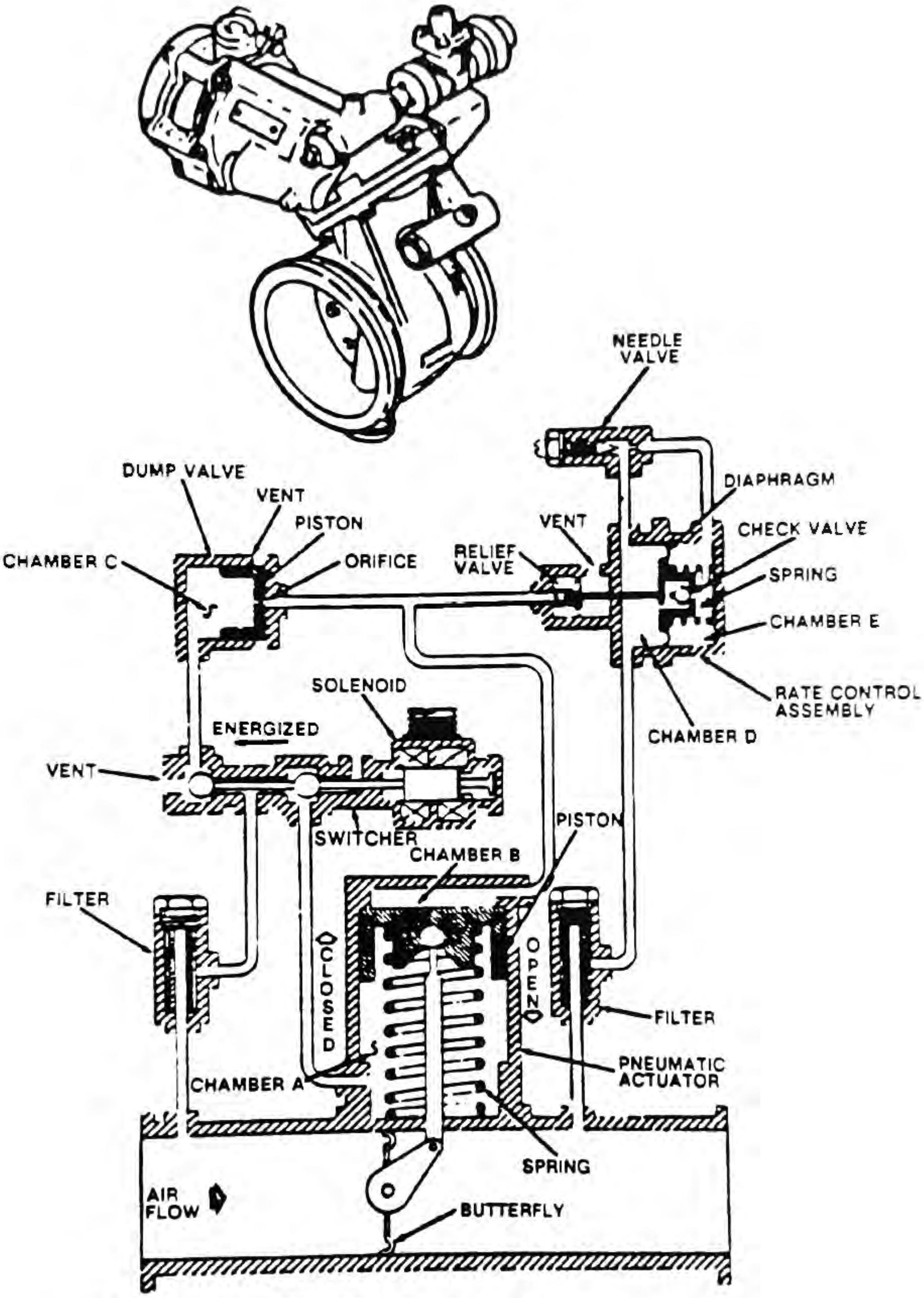
(4) Cabin Compressor Oil Overheat Switch

The cabin compressor oil overheat switch is a temperature-sensitive switch installed in the bottom of the oil sump of each cabin compressor. An electrical connector is incorporated in the switch for connection into the airplane wiring. When oil temperature reaches 250 (±10)°F (121.1 (±5.5)°C), the switch closes and completes the circuit to energize the compressor overheat warning light.

(5) Cabin Compressor Turbine Shutoff Valve

(a) The cabin compressor turbine shutoff valves are electrically controlled, pneumatically operated valves which start and stop the cabin compressors by controlling the supply of pneumatic manifold air to the turbines. One valve is installed in a duct connected between the pneumatic manifold and each cabin compressor. The valve consists of a two-position, solenoid-controlled switcher assembly, a pneumatically actuated butterfly assembly, and a rate control assembly which regulates the valve opening time. A mechanical indicator is installed on the butterfly shaft to indicate the position of the butterfly.

(b) When the solenoid is deenergized, the switcher assembly is in the valve closed position (Figure 21-20). Air pressure sensed upstream of the valve is directed through the air filter to the switcher assembly and then is directed to actuator Chamber A. Chamber C is simultaneously vented to ambient through the switcher assembly. Pressure in Chamber A, plus actuator spring force, results in piston movement to close the butterfly. Air pressure in Chamber B increases because of actuator piston movement and results in the dump valve piston moving off the piston seat, venting the pressure in Chamber B to ambient. The closing rate varies between 0.13 and 0.25 seconds.



CABIN COMPRESSOR TURBINE SHUTOFF VALVE

FTX80326

Figure 21-20

(c) With the solenoid energized in the valve open position, upstream air pressure is routed through Chamber C of the dump valve assembly and through an orifice to actuator Chamber B. Simultaneously, Chamber A is vented to ambient through the switcher assembly. As Chamber B pressure increases on the piston head, actuator spring force is overcome, causing the piston to move the butterfly towards the open position. As the butterfly opens, downstream pressure is directed through a second filter to Chamber D in the rate control assembly. Chamber D pressure is then metered at a predetermined rate by the needle valve into Chamber E. when Chamber D pressure rises to a value sufficient to overcome Chamber E pressure and spring force, the diaphragm moves against the spring to unseat the relief valve. This results in actuator chamber B pressure venting to ambient, relieving the pressure on the actuator piston and retarding the rate of butterfly opening. Thus the opening rate of the butterfly, approximately 3 seconds minimum, is pneumatically controlled by the differential pressure across the rate control diaphragm and prevents excessive acceleration of the compressor during starting. Excessive back pressure in Chamber E is vented through the check valve to Chamber D.

(6) Cabin Compressor Discharge Check Valve

Because adjacent compressors connect to a common delivery duct, a cabin compressor discharge check valve is installed on the outlet diffuser of each cabin compressor. This prevents reverse flow through a compressor when discharge pressure of the adjacent compressors is high.

(7) Compression Heating Recirculation Valve

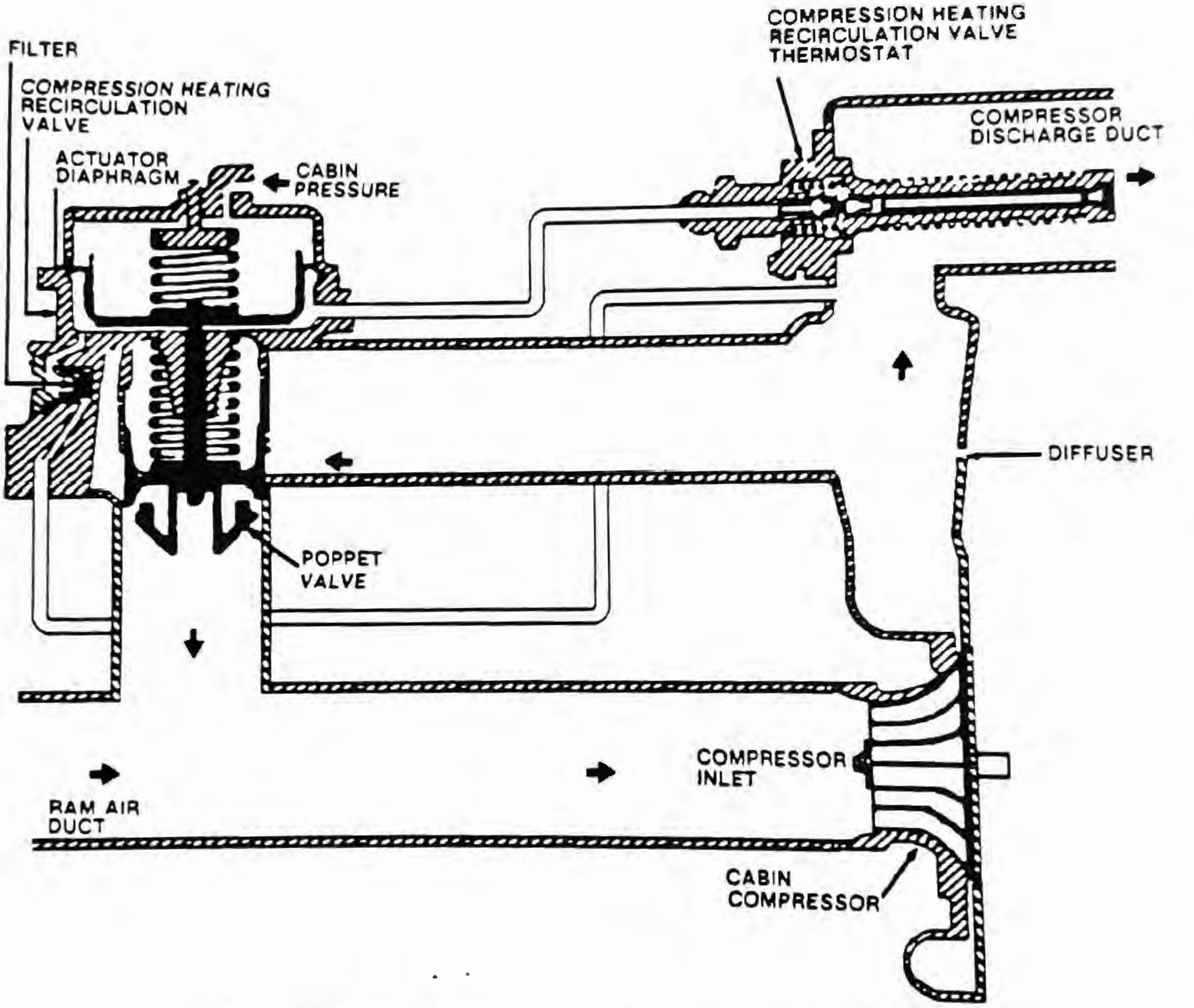
(a) The compression heating recirculation valve operates to provide additional heating of compressor discharge air by ducting a portion of the discharge air back through the compressor. Valve operation depends on pressure differential across the mixing valve. The compression heating recirculation valve is a pressure-actuated diaphragm-type valve. One recirculation valve is located between each cabin compressor discharge duct and ram air inlet duct. The valve incorporates a spring-loaded actuator diaphragm, an air inlet and an air discharge port, a compressor duct pressure-sensing port on the bottom side of the valve, and a cabin air pressure-sensing port at the top. One additional port on the side of the valve is connected to the compression heating recirculation valve thermostat.

(b) Compressor discharge duct pressure is sensed at the compressor diffuser and directed through the filter to the lower chamber of the compression heating recirculation valve (Figure 21-21). The upper chamber is connected by sense lines to cabin pressure. A differential pressure of approximately 2.0 psi on the bottom of the diaphragm is sufficient to begin opening the valve. The valve is fully open at approximately 6.2 psi. As the valve opens, heated discharge air from the compressor is recirculated through to the compressor inlet for further heating.

(8) Compression Heating Recirculation Valve Thermostat

(a) A compression heating recirculation valve thermostat is used to sense and limit the temperature of the air passing through the cabin compressor discharge duct. One thermostat is installed in the discharge ducting of each compressor. The probe of the thermostat extends into the duct and the housing is bolted to a boss which is welded to the duct. The thermostat incorporates a spring-loaded poppet valve, a seat, and a steel actuating piston. The steel piston is brazed to the aluminum valve body at the probe or temperature sensing end.

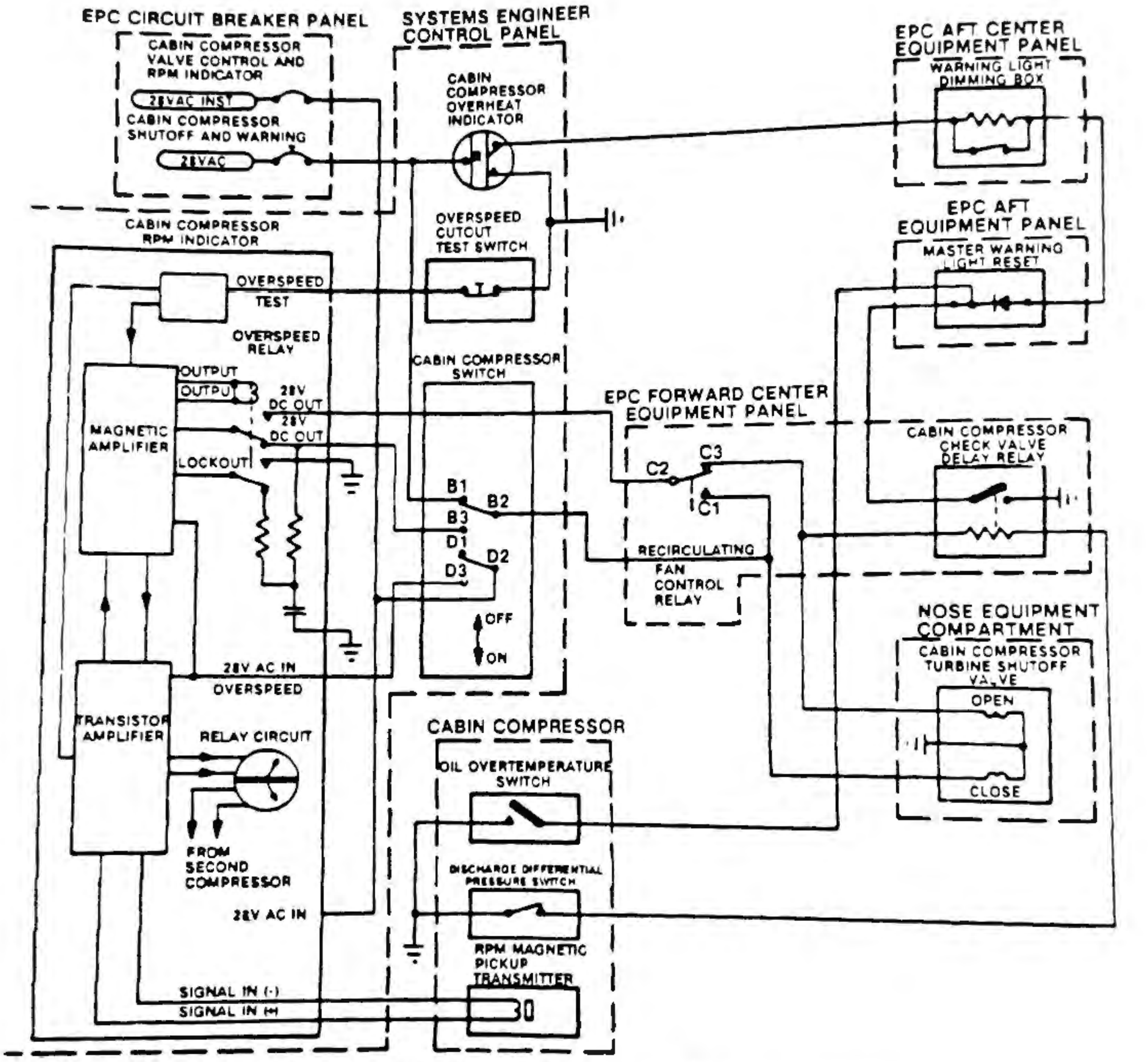
(b) Operation of the thermostat is based on the varying expansion coefficients of dissimilar metals. The aluminum body has a faster expansion rate than the steel piston when exposed to heat, and since the steel piston is not anchored follows the barrel of the aluminum valve body when it expands. Under all temperature conditions up to 200 (±10)°F (93.3 (±5.5)°C the spring-loaded poppet is held closed by the steel piston. Temperatures in excess of this value cause the steel piston to be pulled away from the poppet as the barrel expands. The spring then forces the poppet off the valve seat. This action bleeds pressure from the duct pressure sensing side of the recirculation valve diaphragm, which causes the compression heating recirculation valve to move toward the closed position. As the recirculation valve closes, the recirculation airflow through the compressor is reduced and consequently the air temperature is reduced.


FILTER
COMPRESSION HEATING RECIRCULATION VALVE
ACTUATOR DIAPHRAGM
CABIN PRESSURE
COMPRESSION HEATING RECIRCULATION VALVE THERMOSTAT
COMPRESSOR DISCHARGE DUCT
DIFFUSER
POPPET VALVE
COMPRESSOR INLET
RAM AIR DUCT
CABIN COMPRESSOR

COMPRESSION HEATING RECIRCULATION VALVE

FTX80327

Figure 21-21


EPC CIRCUIT BREAKER PANEL
CABIN COMPRESSOR VALVE CONTROL AND RPM INDICATOR
28VAC INST
CABIN COMPRESSOR SHUTOFF AND WARNING
28VAC
SYSTEMS ENGINEER CONTROL PANEL
CABIN COMPRESSOR OVERHEAT INDICATOR
OVERSPEED CUTOUT TEST SWITCH
CABIN COMPRESSOR SWITCH
B1
B2
B3
D1
D2
D3
OFF
ON
EPC AFT CENTER EQUIPMENT PANEL
WARNING LIGHT DIMMING BOX
EPC AFT EQUIPMENT PANEL
MASTER WARNING LIGHT RESET
EPC FORWARD CENTER EQUIPMENT PANEL
C2
C3
C1
RECIRCULATING FAN CONTROL RELAY
CABIN COMPRESSOR CHECK VALVE DELAY RELAY
NOSE EQUIPMENT COMPARTMENT
CABIN COMPRESSOR TURBINE SHUTOFF VALVE
OPEN
CLOSE
CABIN COMPRESSOR RPM INDICATOR
OVERSPEED TEST
OVERSPEED RELAY
OUTPUT
OUTPUT
28V DC OUT
28V DC OUT
MAGNETIC AMPLIFIER
LOCKOUT
28V AC IN
OVERSPEED
TRANSISTOR AMPLIFIER
RELAY CIRCUIT
FROM SECOND COMPRESSOR
28V AC IN
SIGNAL IN (-)
SIGNAL IN (+)
CABIN COMPRESSOR
OIL OVERTEMPERATURE SWITCH
DISCHARGE DIFFERENTIAL PRESSURE SWITCH
RPM MAGNETIC PICKUP TRANSMITTER

CABIN COMPRESSOR CONTROL CIRCUIT

FTX80328

Figure 21-22

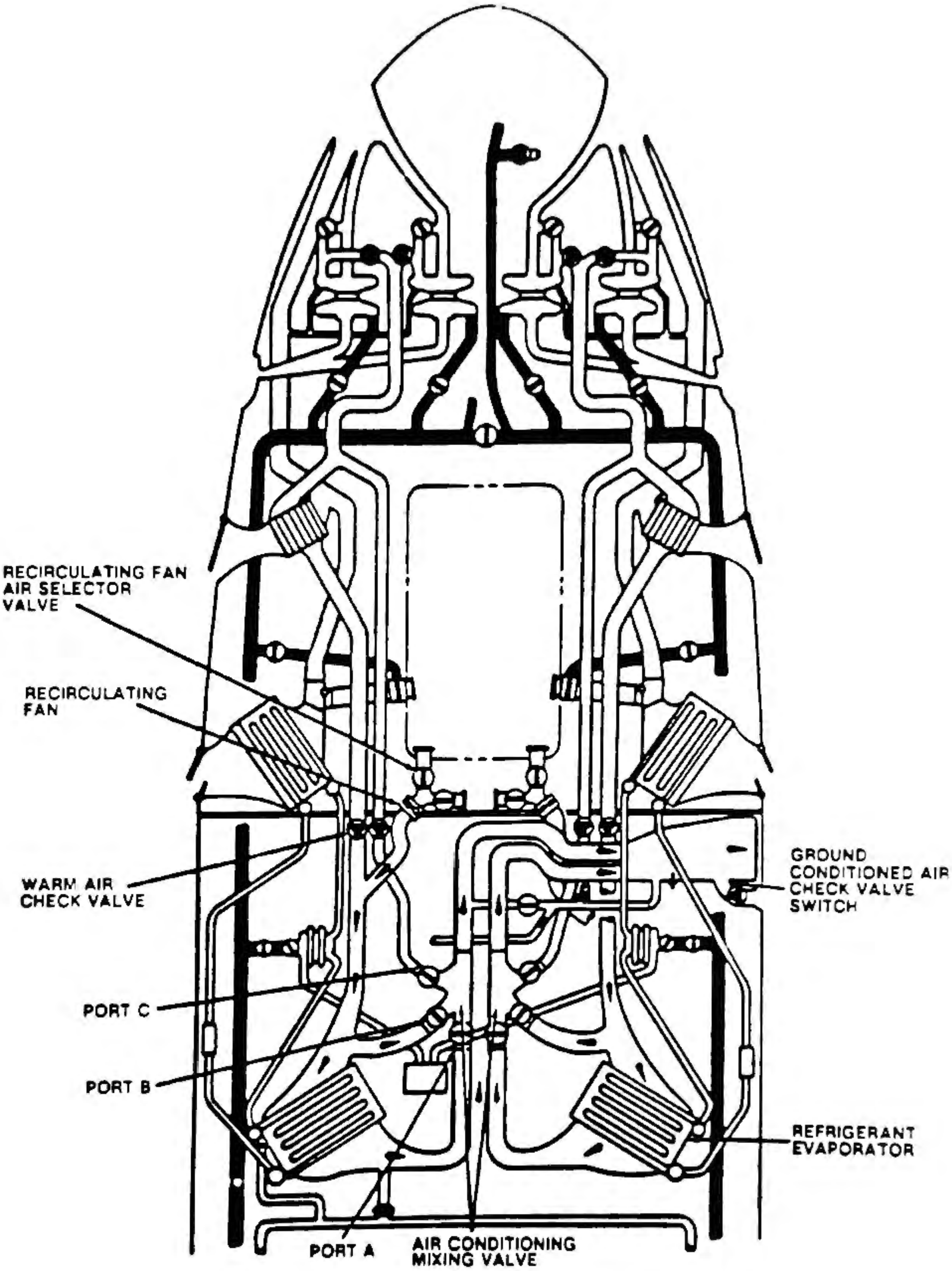
(3) The frequency of the signal from the cabin compressor magnetic pickup transmitter is directly related to compressor rpm. The low power signal from the transmitter is supplied to the rpm indicator. Electronic circuits within the indicator amplify and convert the input signal to direct current. The direct current is proportional to the frequency of the input signal and is displayed on the indicator dial which is calibrated from 0 to 60,000 rpm.

(4) In the event of compressor overspeed, or during overspeed test (opening contacts of the overspeed cutout test switch), the magnetic amplifier is desaturated causing the overspeed relay to deenergize. The 28 vdc output signal is now directed through contacts B2 and B1 of the cabin compressor switch to the close solenoid of the turbine shutoff valve. The valve closes and pneumatic pressure to the turbine section of the compressor is shut off. The valve-closing signal is initiated, when the operating cabin compressor exceeds an indicated speed of 50,000 (+1000) rpm. Variations in temperature and supply voltage can cause the cutoff speed to vary by ±1000 rpm, while the indication section tolerance may vary ±1800 rpm.

(5) During operation, a cabin compressor must overcome a back pressure when discharging output air into the delivery duct. It is possible under certain conditions for the back pressure to overcome the discharge pressure of the compressor. This condition normally exists momentarily during compressor starting; but, if a malfunction causes the condition to exist for a considerable time, compressor damage may result. The cabin compressor discharge differential pressure switch, in conjunction with the cabin compressor check valve delay relay and warning light circuits, functions to notify personnel when this condition continues beyond a normal period. The cabin compressor discharge differential pressure switch is sensitive to changes in compressor discharge airflow relative to inlet pressures. With an increasing airflow, the normally closed contacts of the pressure switch open when differential pressure reaches approximately 20 inches of water maximum. A decreasing airflow closes the contacts at 10 (±2) inches of water. When the cabin compressor switch is placed in on position, the delay relay heating circuit is energized through compressor switch contacts A2 and A3 and through closed contacts of the discharge differential pressure switch. If a differential pressure of approximately 20 inches of water maximum is not attained in approximately 15 seconds, the discharge differential pressure switch contacts close to energize the heater element. Sufficient heat is gen-

erated to actuate the thermal switch within the delay relay. The thermal switch completes the ground return of the compressor overheat warning light circuit, causing the light to come on.

(6) Also included in the compressor overheat warning circuitry is the cabin compressor oil overtemperature switch. The switch is set to close when temperature of the lubricating oil in the sump reaches 250 (+10)°F (121.1) (+5.5)°C. The switch remains closed and the light remains on, until temperature of the oil cools to the opening temperature of the switch.


RECIRCULATING FAN AIR SELECTOR VALVE
RECIRCULATING FAN
WARM AIR CHECK VALVE
PORT C
PORT B
PORT A
AIR CONDITIONING MIXING VALVE
GROUND CONDITIONED AIR CHECK VALVE SWITCH
REFRIGERANT EVAPORATOR

RECIRCULATING FAN AIRFLOW

FTX80332

Figure 21-24

3. Distribution - Description and Operation

A. General

The distribution section is divided into two systems; cabin air recirculating fan control system and distribution systems. The cabin air recirculating fan control section describes the operation of the recirculating fans and control circuit tie-in with other systems. The distribution systems section describes duct and valve layout; flow details of ram air, hot air, warm air, cold air, conditioned air, and exhaust air. Also described in this section are details of components not directly related to the control and operation of the recirculating fans.

4. Cabin Air Recirculating Fan Control - Description and Operation

A. General (Figures 21-23 & 21-24)

A recirculating fan for each air-conditioning system provides ventilation on the ground, recirculation on the ground, and recirculation in flight. The recirculating fans are normally operated on the ground only. Ventilation of the passenger and flight compartments with outside air is provided by positioning the recirculating fan air selector valve to flow outside air into the air conditioning system. Ventilation is possible on the ground if the airplane pneumatic manifold is unpressurized (therefore the refrigeration system cannot operate), and the air-conditioning mixing valve is demanding cooling air. Under all other conditions, the air selector valve is positioned for recirculating internal air within the fuselage. Operation of the recirculating fan control system also depends on the position of the ground control relays, position of the cabin compressor shutoff switches, and non-delivery of conditioned air into the system from an external source. If one or both cabin compressors of the applicable air conditioning system are inoperative in flight, a recirculating fan can be used by placing the appropriate recirculating fan switch to the on position.

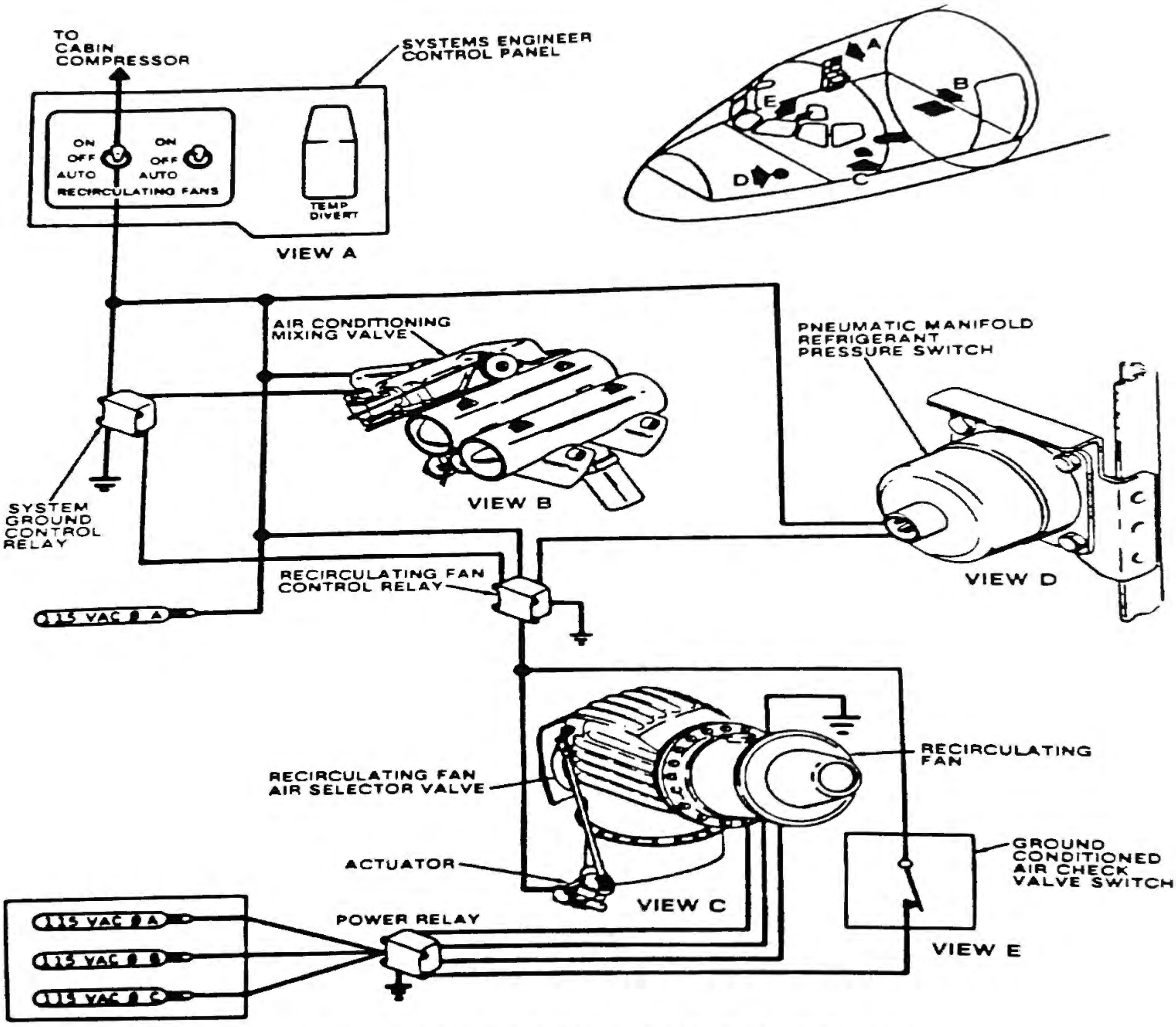
B. Component Description

(1) Recirculating Fan (Figure 21-25)

(a) The recirculating fan is a single-stage, axial-flow, electrical motor-driven fan that can be used for both flight and ground operation. A fan is installed between the recirculating fan air selector valve and the refrigerant evaporator air inlet header of both left and right air-conditioning systems. The fans are located in the air-conditioning accessory compartment on each side of the airplane centerline.

(b) On the ground, the recirculating fans provide the required airflow through the refrigerant evaporators by drawing air from the air-conditioning accessory compartment. When the airplane pneumatic manifold is unpressurized (and therefore the refrigeration system is inoperative), the recirculating fans can be used to supply outside air for ventilation. In flight, the fans recirculate passenger and flight compartment air, and are used to replace the airflow of a nonoperating cabin compressor. Operation or nonoperation of the fans is determined by the position of the air-conditioning mixing valves and by the positions of the recirculating fan switches and cabin compressor switches.

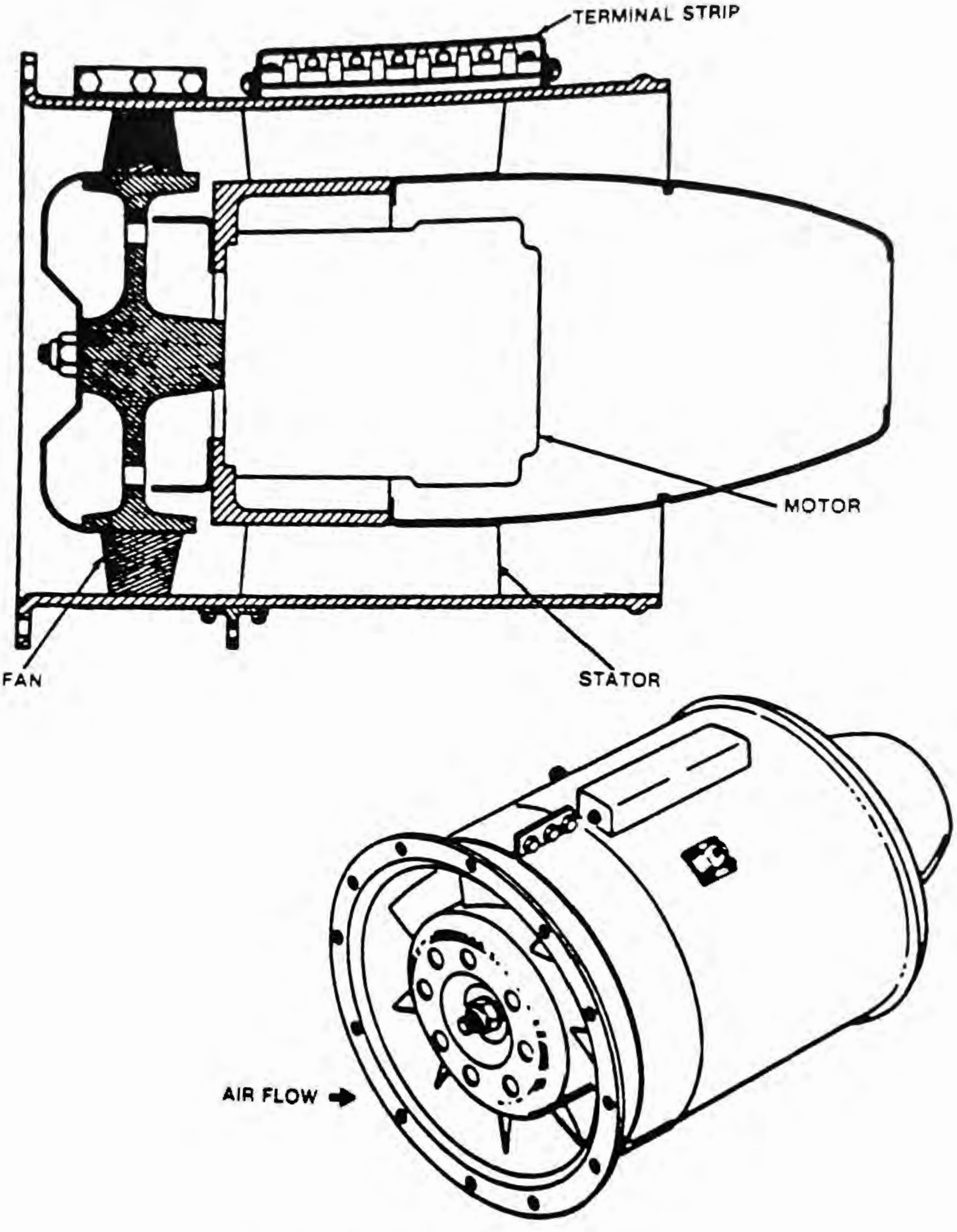
(c) The fan assembly includes the fan and fan motor, both enclosed in a magnesium housing. A terminal strip with five terminal posts is mounted on the housing for the electrical connections to the motor. The fan rotor is installed on the motor shaft and rotates in a counterclockwise direction. The recirculating fan motor is protected from an overheat condition by a thermal protector switch. The switch shuts off the motor before the temperature of the motor case exceeds approximately 450°F (232°C). To reset the switch, the discharge end of the fan must be packed with dry ice and cooled to a temperature between -20° and -65°F (-29° and -54°C).


TO CABIN COMPRESSOR
SYSTEMS ENGINEER CONTROL PANEL
ON
OFF
AUTO
ON
OFF
AUTO
RECIRCULATING FANS
TEMP DIVERT
VIEW A
A
B
C
D
E
AIR CONDITIONING MIXING VALVE
VIEW B
PNEUMATIC MANIFOLD REFRIGERANT PRESSURE SWITCH
VIEW D
SYSTEM GROUND CONTROL RELAY
RECIRCULATING FAN CONTROL RELAY
115 VAC ø A
RECIRCULATING FAN
RECIRCULATING FAN AIR SELECTOR VALVE
ACTUATOR
VIEW C
GROUND CONDITIONED AIR CHECK VALVE SWITCH
VIEW E
POWER RELAY
115 VAC ø A
115 VAC ø B
115 VAC ø C

CABIN AIR RECIRCULATING FAN CONTROL

FTX80329

Figure 21-23



RECIRCULATING FAN

Figure 21-25

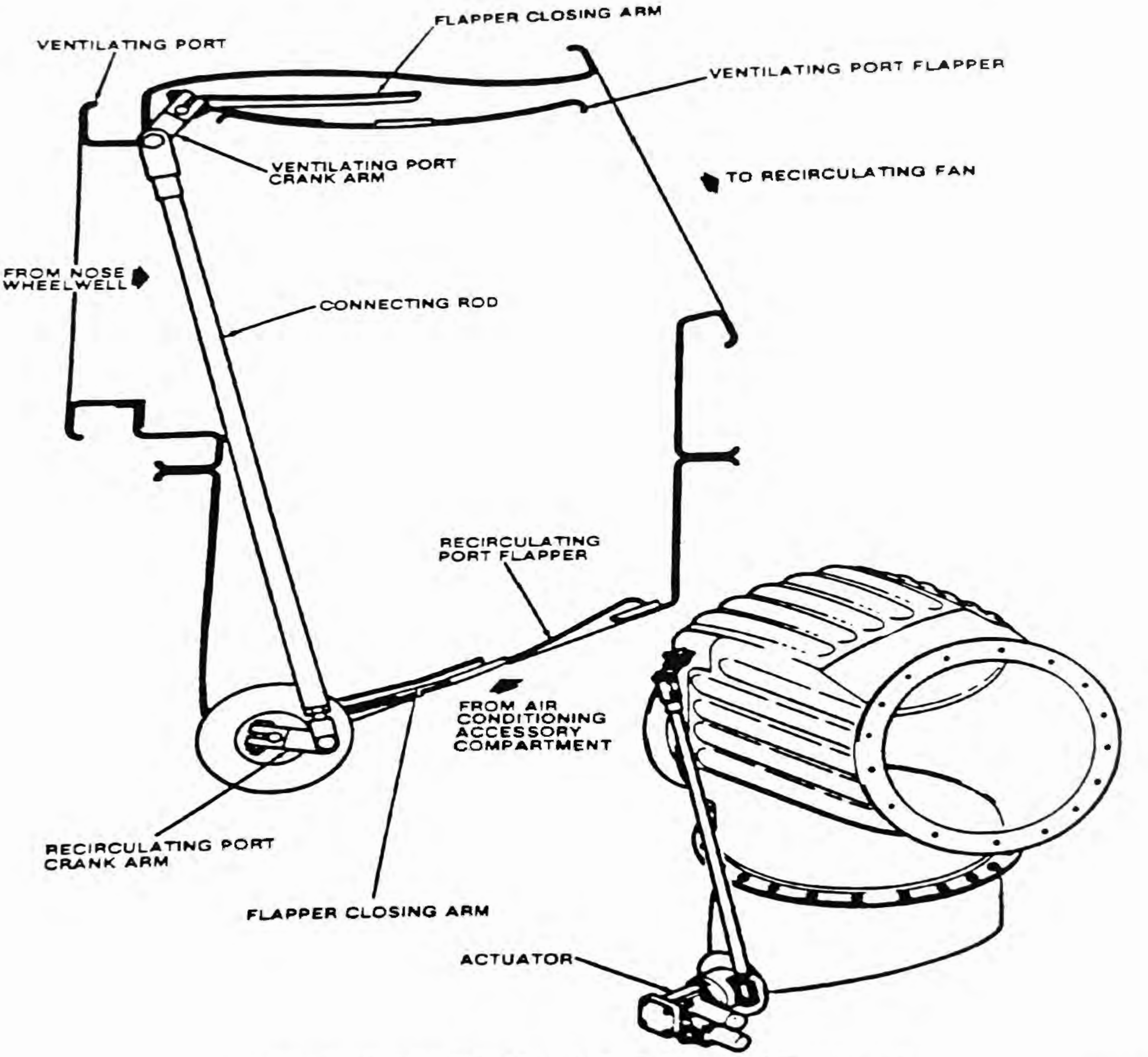
FTX80330

(2) Recirculating Fan Air Selector Valve (Figure 21-26)

(a) The recirculating fan air selector valve selects either a ventilating or a recirculating air source for the recirculating fan. The selector valve is mounted on the forward pressure bulkhead of the air-conditioning accessory compartment, with the ventilating inlet port open to the nose-wheel well area, and the recirculating inlet port open to the air-conditioning accessory compartment. The outlet port of the selector valve is bolted to a recirculating fan. One valve is provided for each air-conditioning system.

(b) Each inlet port incorporates a flapper closing arm, a free swinging flapper, and a shaft with a crank arm attached. The crank arms of each shaft are interconnected by a connecting rod, so that when one shaft rotates clockwise the other rotates counterclockwise. The flapper closing arms which are not directly connected to the flappers are so positioned on the shafts that when the flapper of one port is held closed, the other can flap freely between the open and closed position (Figure 21-26). The free-swinging flapper can be closed by a back pressure through a nonoperative recirculating fan, or opened by the force of the air flowing to the fan (similar to the action of a check valve). An electromechanical actuator is splined to the outer end of the recirculating port crank arm to drive the recirculating port shaft directly, and the ventilating port shaft through the connecting rod.

(c) In flight, the cabin pressure holds both flappers closed when the recirculating fan is not operating. The ventilating port is open only when the airplane is on the ground with the recirculating fan switch in automatic position, the airplane pneumatic manifold unpressurized, and the air-conditioning mixing valve between 0 and 97.5 degrees of camshaft rotation when the valve is adjusting from hot to cold. If the valve is running from cold to hot from a position above 97.5 degrees, the ventilation port does not open until the camshaft reaches 37.5 degrees. The air selector valve actuator drives the flapper closing arm so that the ventilating port flapper is held closed under all other conditions.



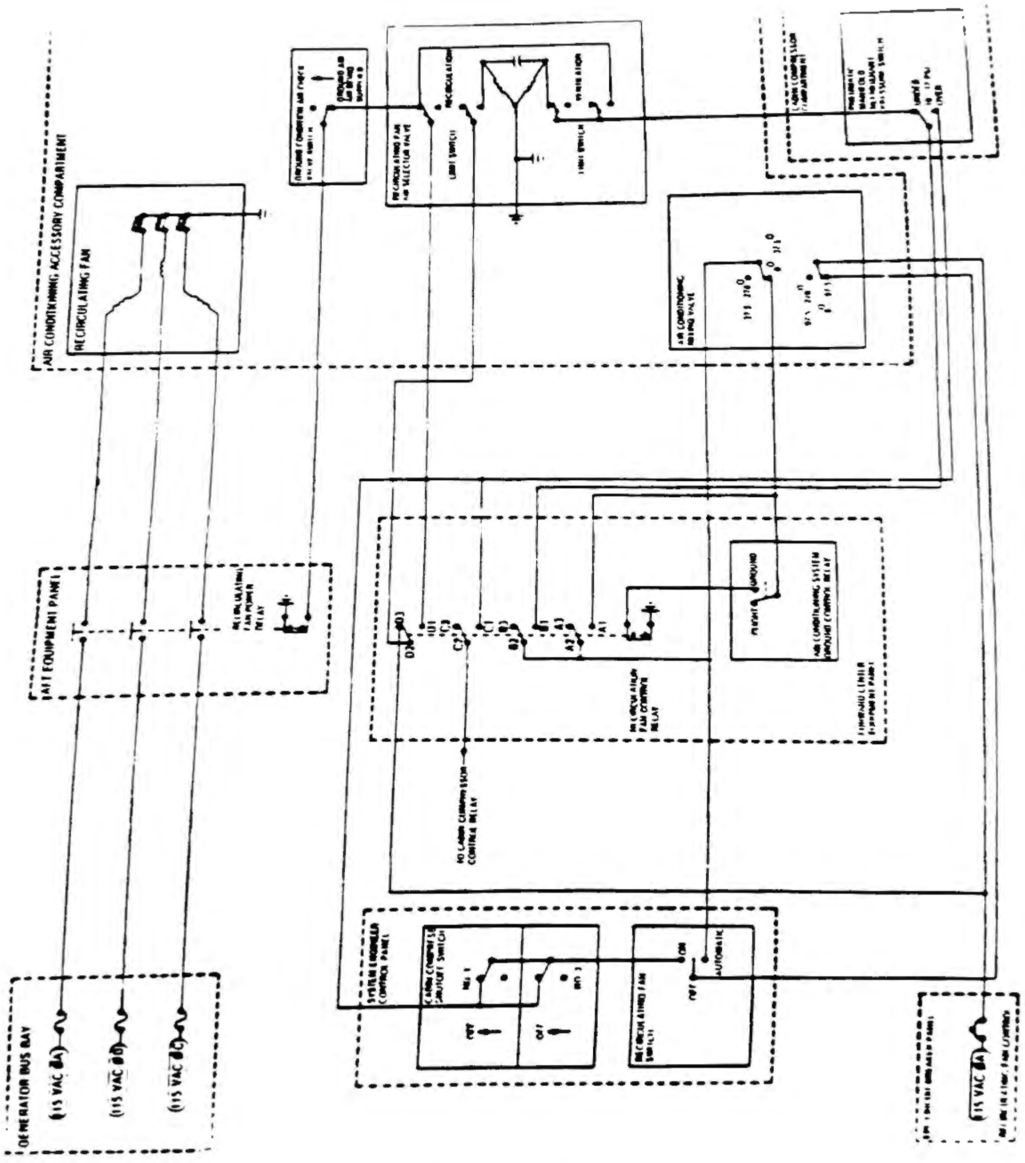
RECIRCULATING FAN AIR SELECTOR VALVE

Figure 21-26

C. System Operation

(1) Normal flow of air to the passenger and flight compartments from the air-conditioning system is through the conditioned and cold air distribution ducts. Exhaust air from the passenger compartment flows through grills below the sidewall panels, through openings in the floor structure, to the utility tunnels. With the recirculating fans operating, flow is from the utility tunnels into the air-conditioning accessory compartment where the recirculating fans are located. The recirculating fans draw air into the recirculating fan air selector valves for recirculation through the air-conditioning system. When the airplane is on the ground the recirculating fans can also draw outside air for ventilation into the air-conditioning system from the nosewheel well area.

(2) A recirculating fan switch (Figure 21-27) controls operation of each recirculating fan, one for each air-conditioning system. Each switch can be placed in the on, off, or automatic position. When 115 vac is applied to the airplane electrical buses and the recirculating fan switch is in off position, the recirculating fan air selector valve moves to the recirculation position (if not already in that position) through closed contacts D2 and D3 of the recirculating fan control relay. The recirculating fan switch is armed through the 0- to 97.5-degree air-conditioning mixing valve switch contacts, if the valve is within this range. When the recirculating fan switch is placed to automatic position, with the airplane on the ground, and the mixing valve is demanding cold air and is between 0 to 37.5 degrees of rotation, the recirculating fan control relay coil is energized. Contacts A1 and A2 of the relay close to electrically lock in the power circuit to the relay coil, regardless of the position of the 0- to 37.5-degree switch in the mixing valve. However, when the mixing valve camshaft rotates beyond the 97.5-degree position, the 0- to 97.5-degree switch contacts open (Figure 21-27), power to the recirculating fan switch is removed, and the recirculating fan control relay coil is deenergized.


GENERATOR BUS BAY
115 VAC ØA
115 VAC ØB
115 VAC ØC
AFT EQUIPMENT PANEL
RECIRCULATING FAN POWER RELAY
AIR CONDITIONING ACCESSORY COMPARTMENT
RECIRCULATING FAN
RECIRCULATION
LIMIT SWITCH
VENTILATION
SYSTEM ENGINEER CONTROL PANEL
CABIN COMPRESSOR SHUTOFF SWITCH
OFF
NO. 1
NO. 3
RECIRCULATING FAN SWITCH
ON
OFF
AUTOMATIC
TO CABIN COMPRESSOR CONTROL RELAY
D3
D2
D1
C3
C2
C1
B3
B2
B1
A3
A2
A1
RECIRCULATION FAN CONTROL RELAY
FLIGHT
GROUND
AIR CONDITIONING SYSTEM GROUND CONTROL RELAY
FORWARD CENTER EQUIPMENT PANEL
AIR CONDITIONING MIXING VALVE
CABIN COMPRESSOR COMPARTMENT
UNDER
OVER
115 VAC ØA

CABIN AIR RECIRCULATING FAN CONTROL

FTX80333

Figure 21-27

(3) When the recirculating fan control relay coil is energized, with the recirculating fan switch in automatic position, and more than 10 to 12 psi available at the airplane pneumatic manifold, the air selector valve is actuated to the recirculation position through contacts B1 and B2 of the relay and contacts of the pneumatic manifold refrigerant pressure switch. The circuit to the recirculating fan power relay coil is energized through the air selector valve limit switch and the ground conditioned air check valve switch. Energizing the coil closes the relay contacts to supply power from the generator bus to the recirculating fan. If no pressure is available at the pneumatic manifold, power is directed to the ventilating actuator of the air selector valve; power is maintained at the fan, but air is drawn from outside to perform the cooling function of the air-conditioning system. Since the coil of the recirculating fan control relay cannot be energized in flight, ground contacts C1 and C2 form part of the control circuit of the cabin compressor control relay.

(4) In flight, the pneumatic manifold refrigerant pressure switch. the 0- to 37.5-degree mixing valve switch, and the system ground control relay have no control over fan operation. To operate a recirculating fan in flight, the recirculating fan switch must be placed to the on position, at least one of the cabin compressors shutoff switches on the applicable side must be in the off position, and the mixing valve camshaft must be positioned to 97.5 degrees or below. Power is routed through the air selector valve, through the ground conditioned air check valve switch to the power relay which starts the fan. The air selector valve is always in the recirculation position during flight.

5. Distribution Systems - Description and Operation

A. General

(1) The distribution systems direct the flow of ram air, hot air, warm air, cold air, conditioned air, and exhaust air. Although the flight and passenger air conditioning systems operate independently of each other, the total conditioned air output from the right and left air-conditioning mixing valves are combined in a single (pant leg) duct. By combining the output of the two air conditioning systems before distribution, excess air from the flight compartment (left) air conditioning system is available to augment passenger compartment requirements. Either system can supply conditioned air to both passenger and flight compartments if necessary.

(2) Conditioned air is formed by mixing controlled amounts of hot, warm, and cold air in the air-conditioning mixing valves. Ram air is inducted into four cabin compressors, which then deliver fresh, hot, pressurized air. Warm air is obtained by ducting this air through heat exchangers and cold air is obtained by ducting warm air through refrigerant evaporators. Ram air also provides heat exchanger cooling, cabin compressor oil sump cooling, and refrigerant condenser cooling.

(3) Ground conditioned air supply ducting in the airplane is used to transfer conditioned air from a ground source to the conditioned air ducting of the passenger and flight compartments.

B. Description

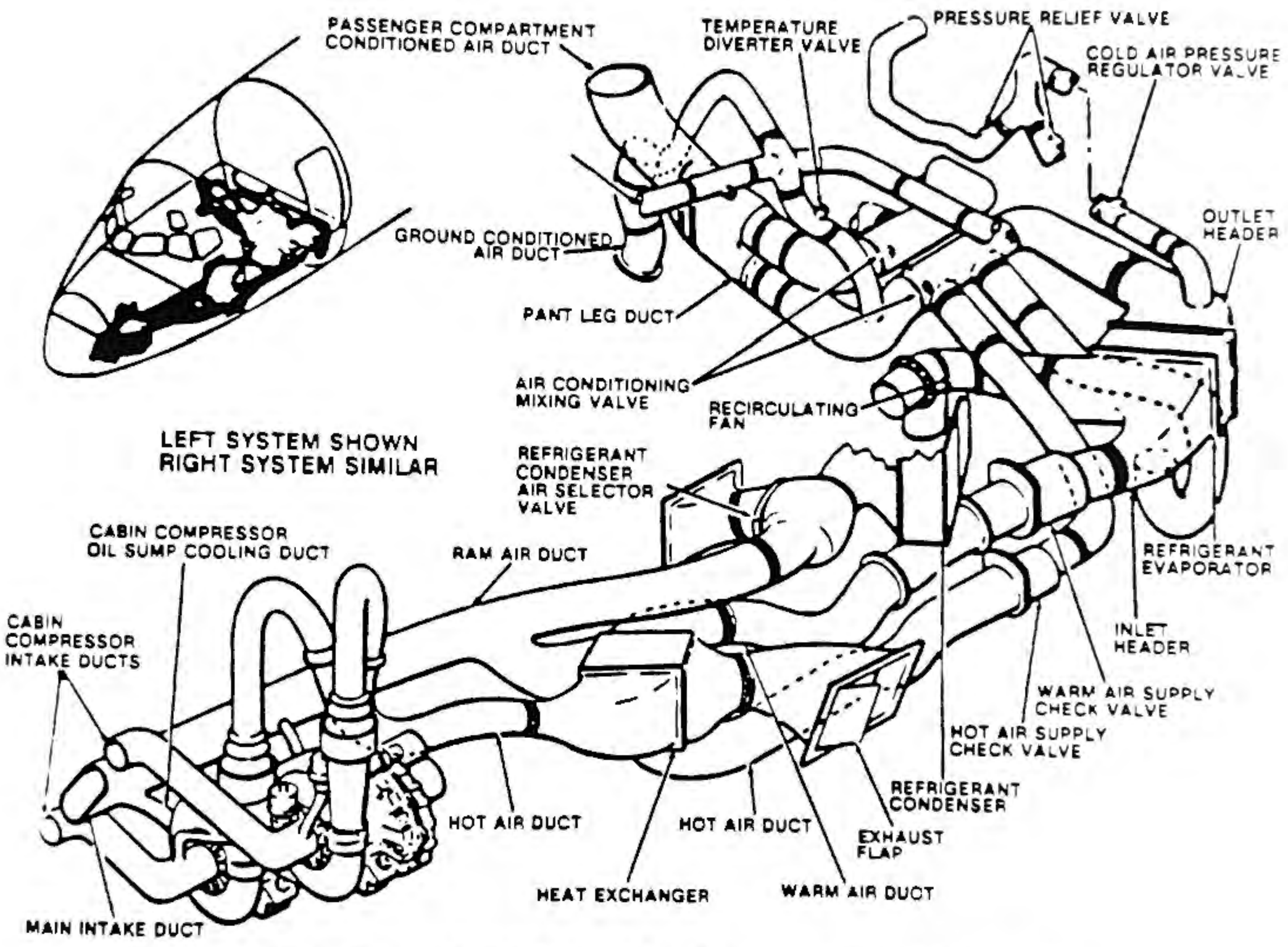
(1) Ram Air Ducting (Figure 21-28)

Two ram airscoops located in the airplane nose, one on each side of the centerline, are connected to four cabin compressor intake ducts and two main ram air ducts. The two main ram air ducts are installed in the lower section of the airplane nose, around the nosewheel well structure and connected to the right and left heat exchangers and refrigerant condenser air selector valves. Each air selector valve has three ports with a flapper to cover either the ram air port or the refrigerant condenser fan port. The refrigerant condenser fan is used for condenser cooling when the airplane is on the ground. The selector valve outlet is connected to the refrigerant condenser. Ducts are connected from the main intake ducts to each cabin compressor oil sump for cooling purposes.

(2) Hot Air Supply ducting

Hot air ducting is provided for each air conditioning system from cabin compressors 1 and 2 on the left side and from cabin compressors 3 and 4 on the right side. Ducting is routed from check valves at the outlets of compressors 1 and 2 to a Y-duct. One outlet of the Y-duct is connected to the heat exchanger inlet header; the other outlet is connected to a duct run that ends at the hot port of the air-conditioning mixing valve in the air-conditioning accessory compartment. This duct contains a check valve that is installed on the forward pressure bulkhead of the air-conditioning accessory compartment. Cabin compressors 3 and 4 are similarly connected on the right side.

AIR CONDITIONING SYSTEM


PASSENGER COMPARTMENT CONDITIONED AIR DUCT
TEMPERATURE DIVERTER VALVE
PRESSURE RELIEF VALVE
COLD AIR PRESSURE REGULATOR VALVE
OUTLET HEADER
GROUND CONDITIONED AIR DUCT
PANT LEG DUCT
AIR CONDITIONING MIXING VALVE
RECIRCULATING FAN
LEFT SYSTEM SHOWN
RIGHT SYSTEM SIMILAR
REFRIGERANT CONDENSER AIR SELECTOR VALVE
CABIN COMPRESSOR OIL SUMP COOLING DUCT
RAM AIR DUCT
REFRIGERANT EVAPORATOR
CABIN COMPRESSOR INTAKE DUCTS
INLET HEADER
WARM AIR SUPPLY CHECK VALVE
HOT AIR SUPPLY CHECK VALVE
REFRIGERANT CONDENSER
HOT AIR DUCT
HOT AIR DUCT
EXHAUST FLAP
HEAT EXCHANGER
WARM AIR DUCT
MAIN INTAKE DUCT

AIR SUPPLY DISTRIBUTION COMPONENT LOCATION

FTX80334

Figure 21-28

(3) Warm Air Supply Ducting

Warm air supply ducts begin at each heat exchanger outlet and are routed to the warm air check valves mounted on the right and left sides of the pressure bulkhead in the air-conditioning accessory compartment. The check valves are connected to the refrigerant evaporator inlet headers. A recirculating fan is mounted on each evaporator header. A duct is routed from each evaporator header to the corresponding air-conditioning mixing valve warm air port.

(4) Cold air Supply and Distribution Ducting

The main cold air supply ducts are connected between the refrigerant evaporator outlet headers and cold ports of the air-conditioning mixing valves (Figure 21-28). A welded duct section from the left refrigerant evaporator outlet header is connected to the cold air pressure regulator valve. In the flight compartment, cold air ducts are routed from the main cold air supply to adjustable outlets for each crew member.

(5) Conditioned Air Distribution Ducting

(a) Conditioned air distribution begins at the outlet ports of each air-conditioning mixing valves. Both outlets are connected to a single (pant leg) duct that forms the main supply duct for the cargo compartment. An outlet for the flight compartment conditioned air is provided upstream of the pant leg duct. From this outlet, ducts equipped with the temperature diverter valve are teed into the main flight compartment conditioned air ducts. Also teed into the flight compartment conditioned air ducts, is a branch duct which is connected into the cargo compartment main ducting downstream of the pant leg duct.

(b) The flight compartment conditioned air main distribution ducts are routed forward to the right and left sides of the air-conditioning accessory compartment (Figure 21-29). The left duct installation contains a muffler below the flight compartment floor, ducts that branch to an overhead diffuser, and ducts that are routed forward to an adjustable outlet at the left forward panel installation. The right duct installation contains ducts that are routed upward through the flight compartment floor, and through a muffler installed adjacent to the airplane skin to an overhead diffuser. Another duct runs forward to adjustable outlets at the right forward panel installation.

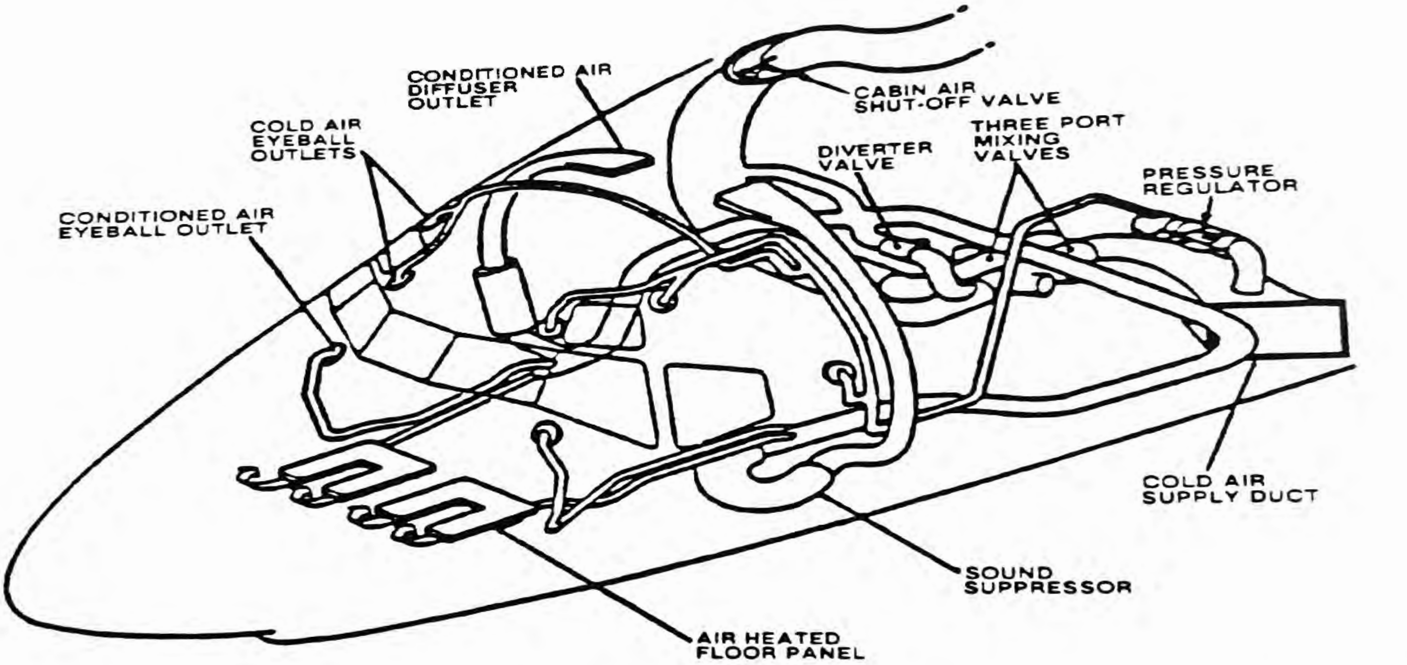
(c) The cabin compartment main air conditioned air duct is routed upward from the air conditioning accessory compartment through a muffler to an overhead duct above the ceiling. The overhead duct terminates just aft of the forward main entry door.

(6) Cabin Air Shutoff Valve

A mechanically operated cabin air shutoff valve is located in the main cabin air distribution duct in the cabin ceiling. The valve is controlled by a handle located in the crew coat closet, and mechanical linkage attached to the cabin air shutoff valve.

(7) Temperature Diverter Valve (Figure 21-30)

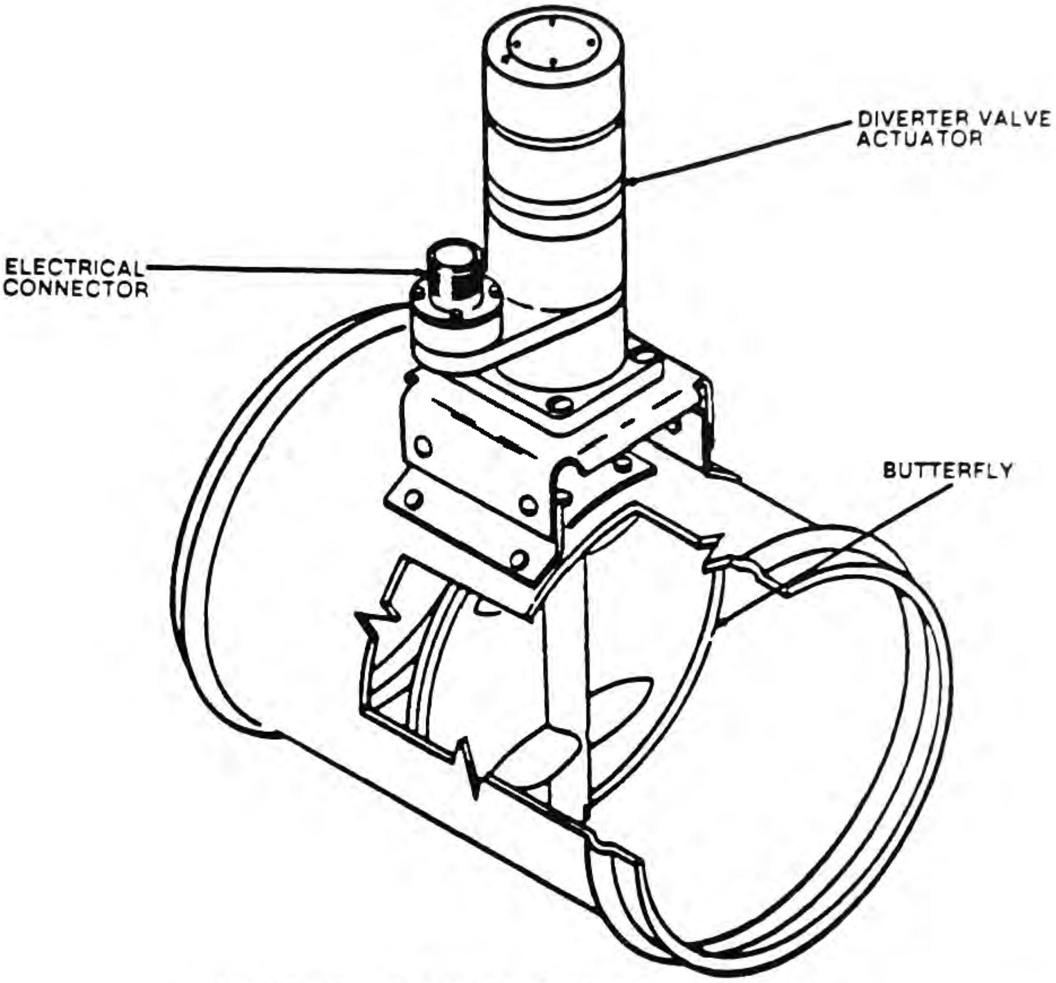
A temperature diverter valve is installed between the flight compartment conditioned air ducts and the outlet of the flight compartment air conditioning mixing valve in the air-conditioning accessory compartment. The butterfly-type valve is driven by an actuator, which consists of a 28-vdc motor, reduction gear, and limit switches. The temperature diverter valve 2-position switch (Figure 21-31) is located on the systems engineer control panel in the flight compartment, and is guarded in the open position. Normally, flight compartment conditioned air is directed from the left air conditioning mixing valve. If the flight compartment air conditioning system is inoperative, closing the diverter valve allows passenger compartment system airflow to be diverted to the flight compartment conditioned air ducts.



CONDITIONED AIR DISTRIBUTION

FTX80335

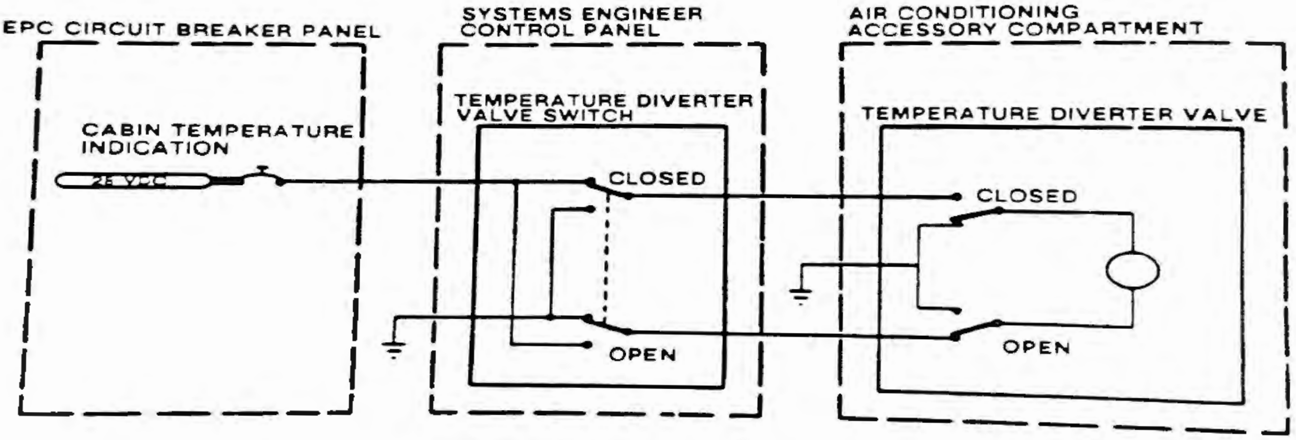
Figure 21-29



TEMPERATURE DIVERTER VALVE

FTX80336

Figure 21-30


EPC CIRCUIT BREAKER PANEL
CABIN TEMPERATURE INDICATION
28 VDC
SYSTEMS ENGINEER CONTROL PANEL
TEMPERATURE DIVERTER VALVE SWITCH
CLOSED
OPEN
AIR CONDITIONING ACCESSORY COMPARTMENT
TEMPERATURE DIVERTER VALVE
CLOSED
OPEN

TEMPERATURE DIVERTER VALVE
ELECTRICAL SCHEMATIC

FTX80337

Figure 21-31

C. System Operation (Figure 21-35)

(1) Ram Air

From scoops in the airplane nose, ram air is routed to the four cabin compressors. The fresh, hot, pressurized air delivered by the cabin compressors is the source of pressure for cabin pressurization and heat for air conditioning. Ram air routed through the main intake duct removes heat from the heat exchangers and refrigerant condensers. The flow of ram air across the heat exchangers and condensers is controlled by flap installations in the ram air exhaust ducts. These flaps are electrically operated and controlled. A portion of ram air from the main intake duct is directed through tubes in the cabin compressor sumps to cool the lubricating oil. On the ground when ram air is not available, a fan performs the cooling function for the refrigerant condenser.

(2) Hot, Warm, and Cold Air Supply

The original source of fresh, hot, pressurized air as delivered by the cabin compressors is called the hot air supply. This air is routed through check valves to the air-conditioning mixing valve hot air port and to inlet headers on the heat exchangers. The temperature of the hot air is reduced in the ram-air-cooled heat exchangers to form the warm air supply. Warm air is routed through a check valve to the mixing valve warm air port. From the check valve, warm air also flows to the inlet header of the refrigerant evaporator, which reduces the temperature further and forms the cold air supply. Cold air is routed to the mixing valve cold air port, and through a takeoff duct from the left refrigerant evaporator outlet header to the cold air distribution system.

(3) Cold Air Distribution

The normal source of cold air for distribution to the passenger and flight compartment cold air outlet (eyeball) valves is from the left refrigerant evaporator outlet header through the cold air pressure regulator valve (Figure 21-35). The pressure regulator valve, controls cold airflow at 10 (±2) inches of water pressure in the distribution duct, and two pressure relief valves protect against overpressurization. Cold air is distributed to flight crew outlets only.

(8) Hot and Warm Air Supply check Valves (Figure 21-32)

(a) The hot and warm air supply check valves contain a free-swinging flapper valve that allows an unrestricted airflow in one direction and prevents airflow in the opposite direction. A hot air check valve is installed between the cabin compressors and mixing valve in the hot air ducts of the left and right air conditioning systems. A warm air supply check valve is installed between the heat exchanger and refrigerant evaporator inlet header of each system. The four valves are installed on the forward pressure bulkhead of the air-conditioning accessory compartment, and function to prevent loss of fuselage pressure if a duct leak occurs outside the pressurized area, or if one system is inoperative.

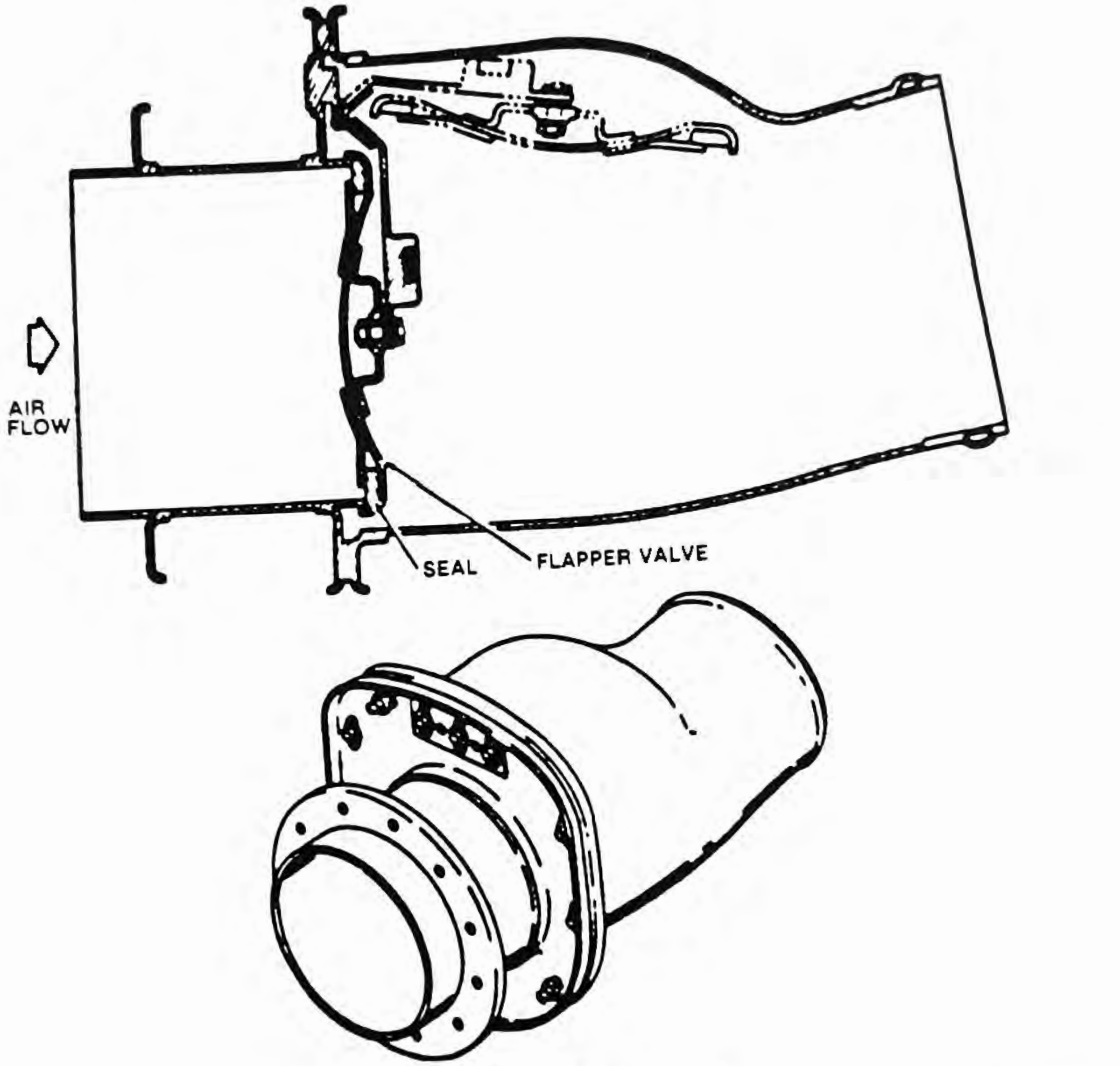
(b) Each valve consists of a valve body, valve seat, and flapper valve. The flapper is hinged at the top of the valve body and is attached with screws to a flange welded to the valve seat. A silicone rubber seal is provided on the flapper valve.

(9) Ground Conditioned Air Inlet Check Valve (Figure 21-33)

The ground conditioned air inlet check valve contains a free-swinging flapper valve that allows airflow in one direction and prevents airflow in the opposite direction. The valve is part of the ground conditioned air inlet duct, which is installed in the air-conditioning accessory compartment, and is connected to the passenger compartment main distribution ducts. The external access door is located on the right side of the nose section. A switch is installed in the duct assembly and is actuated when the flapper valve is fully open. The switch deenergizes the power relay in each recirculation fan motor circuit when ground conditioned air is being delivered at a pressure of approximately 10 inches of water.

(10) Cold Air Pressure Regulator Valve (Figure 21-34)

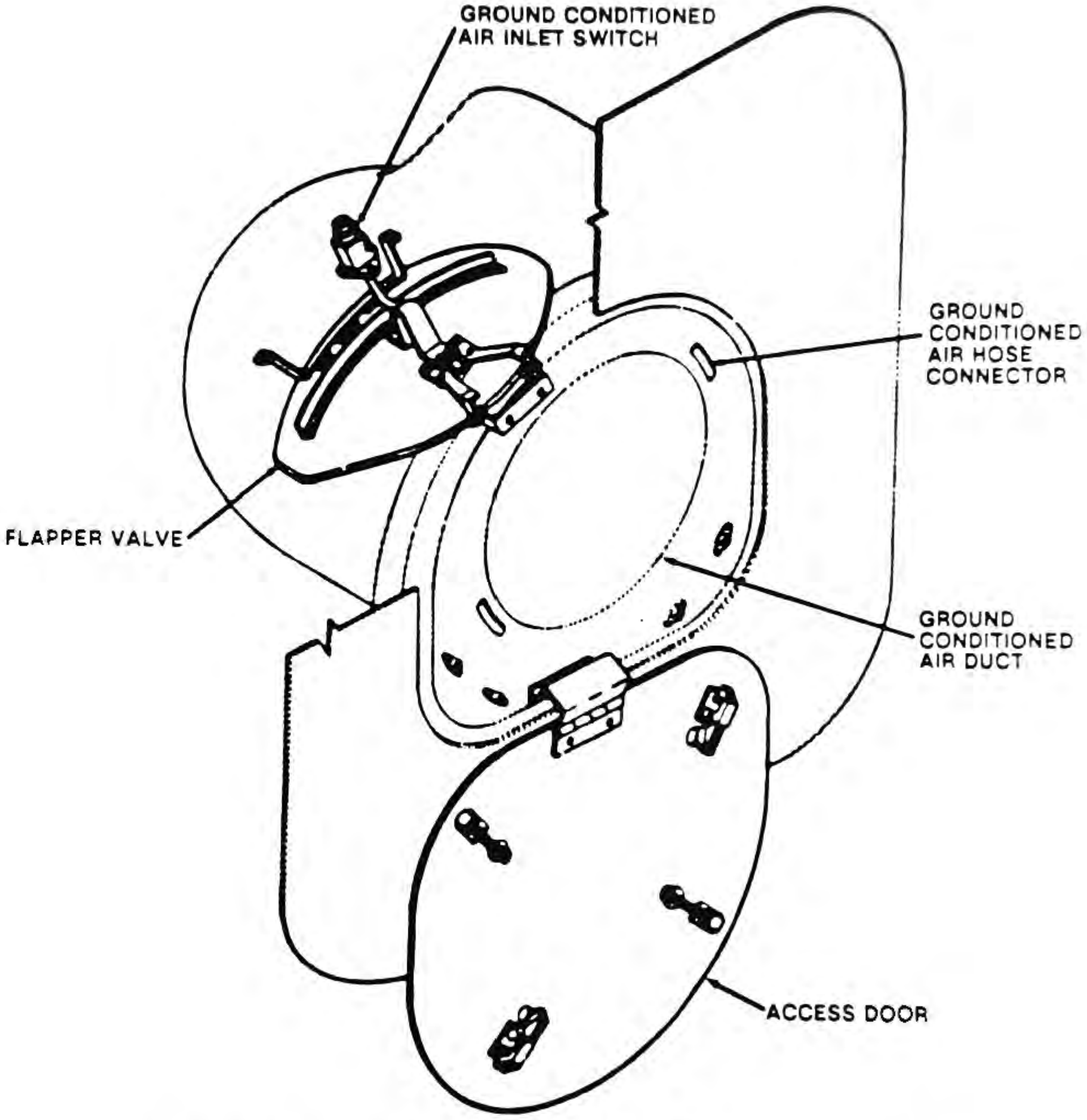
(a) The cold air pressure regulator valve is a normally open, pneumatically actuated, differential control, butterfly-type valve. The valve reduces cold air supply pressure and is installed in the cold air main supply duct in the air-conditioning accessory compartment.



AIR SUPPLY CHECK VALVE

FTX80338

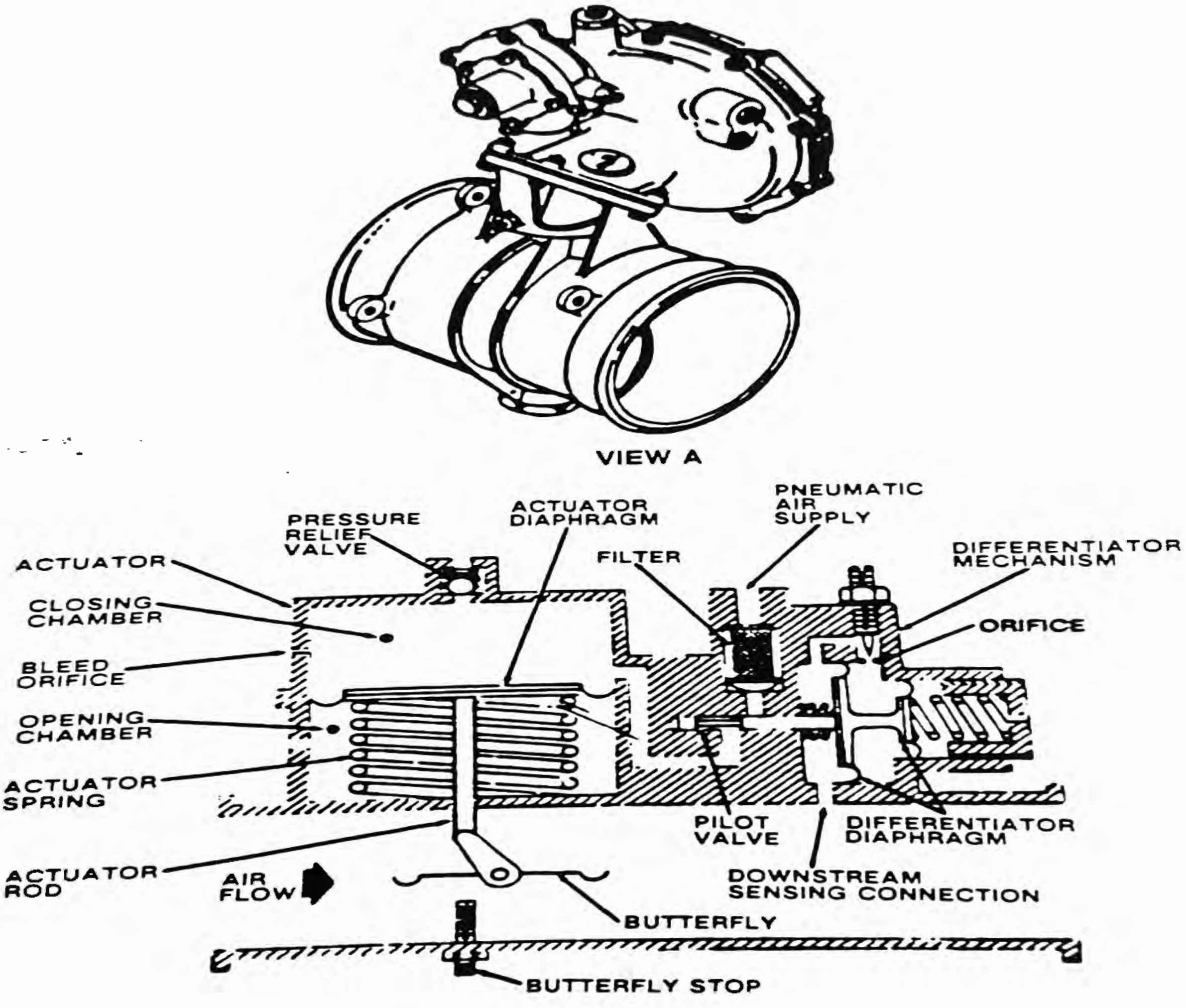
Figure 21-32


GROUND CONDITIONED AIR INLET SWITCH
GROUND CONDITIONED AIR HOSE CONNECTOR
FLAPPER VALVE
GROUND CONDITIONED AIR DUCT
ACCESS DOOR

GROUND CONDITIONED AIR INLET CHECK VALVE

FTX80339

Figure 21-33



COLD AIR PRESSURE REGULATOR

FTX80340

Figure 21-34

(b) The butterfly valve is normally spring loaded open while cold air pressure downstream of the valve is below 10 ± 2 inches of water. As downstream pressure increases, the differentiator diaphragm spring force is overcome and the pilot valve is opened. Filtered pneumatic air enters the closing chamber, overcomes actuator spring force, and moves the butterfly valve toward the closed position. Cold air supply pressure is reduced; therefore, pressure on the differentiator diaphragm is reduced. Spring force returns the differentiator diaphragm to normal, and the pilot valve closes to shut off pneumatic supply pressure. Pressure remaining in the closing chamber is released to ambient through the bleed orifice, maintaining the butterfly valve open until cold air over-pressure repeats the operation.

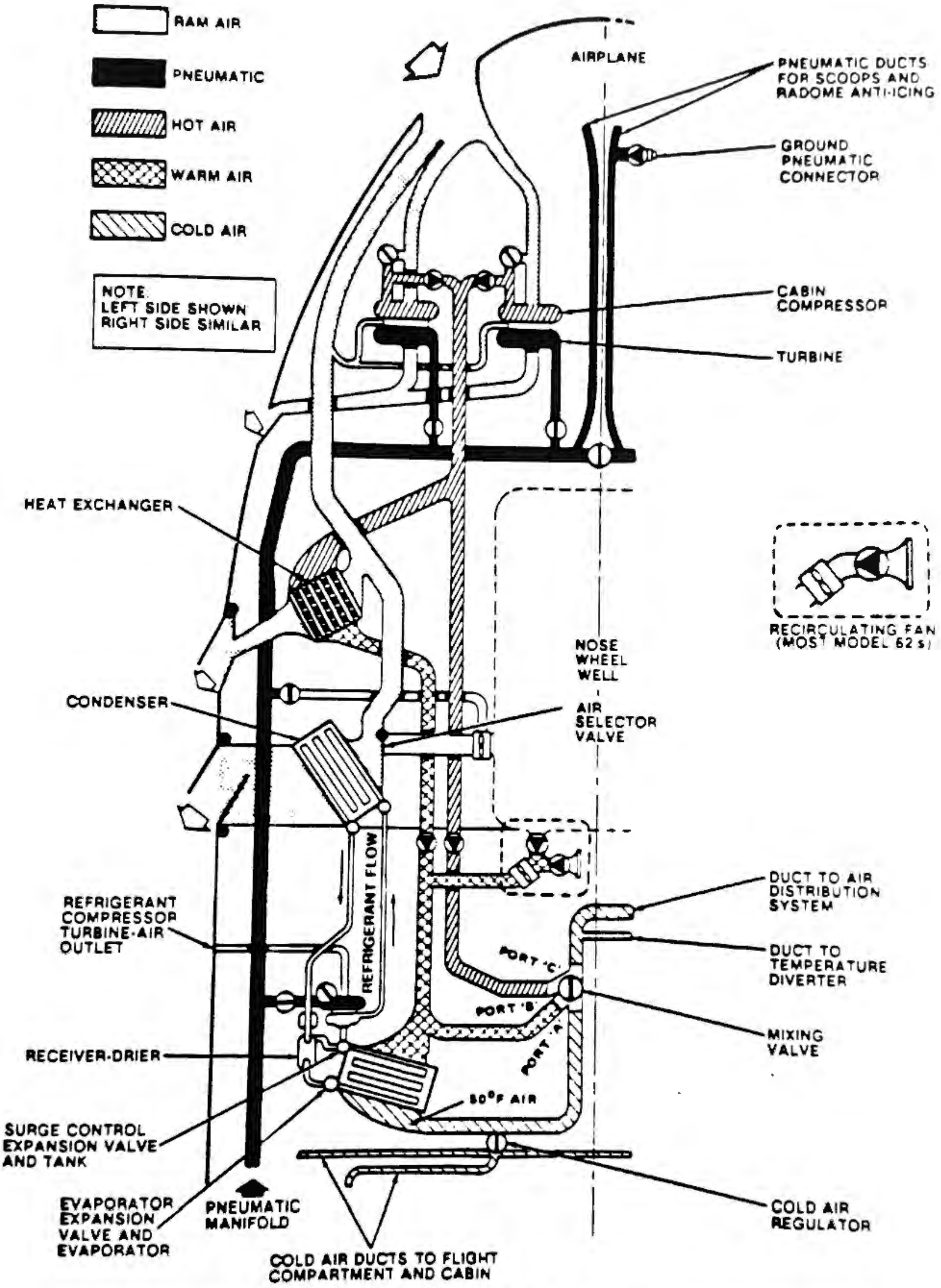
(11) Cold Air Pressure Relief Valve

A cold air pressure relief valve is installed in each of the two legs of the Y-duct located downstream from the pressure regulator valve in the air-conditioning accessory compartment. The relief valves protect the cold air ducting from overpressurization if the cold air pressure regulator valve fails.

(12) Aft Cargo Compartment Blower

(a) The aft cargo compartment blow is used to heat the aft cargo compartment by circulating air between the floor of the compartment and the outer skin insulation. The blower consists of a single stage, axial flow fan driven by a totally enclosed 3-phase, 115-volt electric motor that incorporates internal thermal protection switches. The thermal protectors open to deenergize the motor circuits when the motor temperature exceeds 302 (±9)°F (150 (±5)°C) and close when the motor case cools to a temperature below 197 (±18)°F (92 (±10)°C). Under normal circumstances, the thermal protectors should reset in approximately 10 minutes.

(b) The aft cargo compartment blower is located in the forward end of the left utility tunnel adjacent to the aft cargo compartment. The fan is connected to ducts that direct blower airflow below the compartment floor and is mounted on vibration insulating supports. The blower operates continuously when the radio rack cooling fan switch is in the normal or on position.


RAM AIR
PNEUMATIC
HOT AIR
WARM AIR
COLD AIR
NOTE:
LEFT SIDE SHOWN
RIGHT SIDE SIMILAR
AIRPLANE
PNEUMATIC DUCTS FOR SCOOPS AND RADOME ANTI-ICING
GROUND PNEUMATIC CONNECTOR
CABIN COMPRESSOR
TURBINE
HEAT EXCHANGER
RECIRCULATING FAN (MOST MODEL 62's)
NOSE WHEEL WELL
CONDENSER
AIR SELECTOR VALVE
REFRIGERANT FLOW
DUCT TO AIR DISTRIBUTION SYSTEM
REFRIGERANT COMPRESSOR TURBINE-AIR OUTLET
PORT 'C'
DUCT TO TEMPERATURE DIVERTER
PORT 'B'
MIXING VALVE
PORT 'A'
RECEIVER-DRIER
50°F AIR
SURGE CONTROL EXPANSION VALVE AND TANK
COLD AIR REGULATOR
EVAPORATOR EXPANSION VALVE AND EVAPORATOR
PNEUMATIC MANIFOLD
COLD AIR DUCTS TO FLIGHT COMPARTMENT AND CABIN

REFRIGERATION SYSTEM & RELATED A/C SYSTEM COMPONENTS

FTX80342

Figure 21-35

(4) Conditioned Air Distribution

(a) Conditioned air source begins at the outlets of the left and right air-conditioning mixing valves in the air-conditioning accessory compartment (Figure 21-35). Both supplies are directed into one large (pant leg) duct. At the outlet of the left air conditioning mixing valve, a duct is routed to the flight compartment distribution system. This duct contains the temperature diverter valve which is normally open. The remainder of the conditioned air from the left mixing valve, combined with conditioned air from the right mixing valve, is routed through the main duct and muffler to the aft overhead diffuser through the overhead ducting installations.

(b) Conditioned air is discharged into the flight compartment through two overhead diffusers and two floor outlets (Figure 21-36), one at the captain's feet and one at the first officer's feet. Two adjustable outlets forward and outboard of the captain's and first officer's seats may also be installed for flight crew convenience. If the flight compartment (left) air conditioning system in inoperative, the normally open diverter valve (Figure 21-35) is closed and passenger compartment (right) conditioned air flows into the flight compartment distribution ducts through a duct installed downstream from the passenger compartment main supply.

(5) Exhaust Air Provisions (Figure 21-37)

(a) Air exhausted from the flight compartment is drawn through the radio rack to cool the electrical and electronic equipment and is then used to heat the forward cargo compartment, or is discharged overboard depending on the mode of operation of the radio rack cooling system. When used to heat the cargo compartment, exhaust air is routed through the radio rack blower and between the floor of the forward cargo compartment and the outer skin insulation. Air passing below the cargo compartment floor is exhausted into the right utility tunnel under the passenger compartment floor. Some of the air flows forward to the recirculation fans. The balance flows aft through the accessories compartment and over the wing into utility tunnels on each side of the aft cargo compartment. Part of the air passing into the left utility tunnel aft of the wing is drawn into the aft cargo compartment blower and is directed below the floor of the aft cargo compartment. From the utility tunnels, air flows overboard through the cabin air outflow valve.

(b) Exhaust grills, air flows through openings in the floor structure (cusp diaphragms) to the utility tunnels on each side of the cargo compartments (Figure 21-37). No ventilation is provided in the cargo compartment.

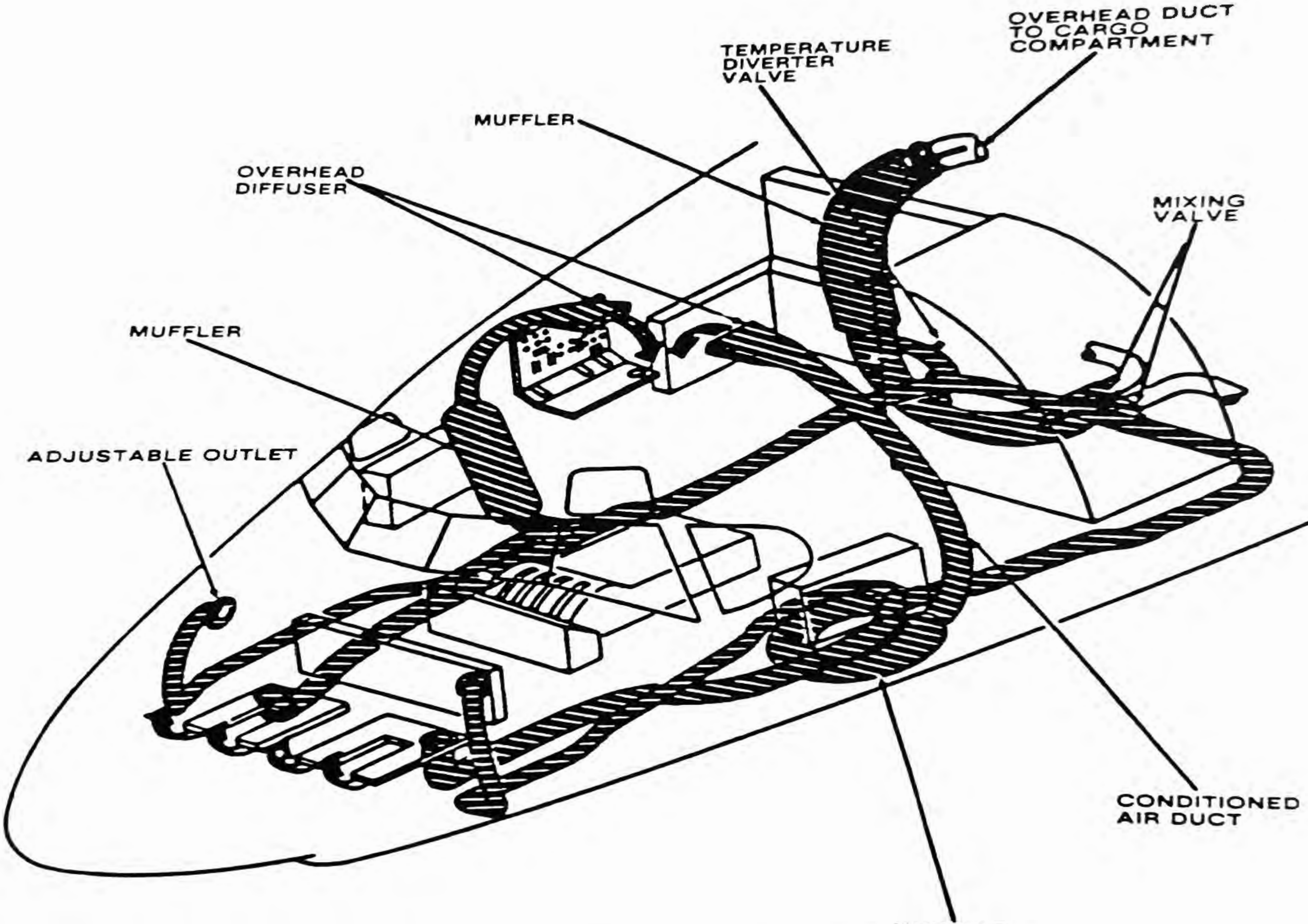
6. Heating - Description and Operation

A. General

(1) Flight compartment floor heating panels and fluted fiberglass panels are provided to warm the flight compartment floor, since the floor is exposed to ambient air temperature conditions. Conditioned air is passed through the fluted panels and is exhausted at floor level near the captain's and first officer's feet to help keep the immediate area warm. There are six electrically operated flight compartment floor heating panels. Four in the systems engineer's area, and one each in the captain's and first officer's areas (Figure 21-38).

(2) The flight compartment floor heater panels are all basically constructed in the same manner, but vary in size and power output. Each panel consists of an electrical heating element imbedded between laminations of fiberglass and impregnated with polyester resin. The heating element is bonded to a sheet of aluminum to form a panel approximately 0.063-inch thick. Two wires attached to the heating element are extended out to an electrical receptacle for connecting to the airplane wiring.

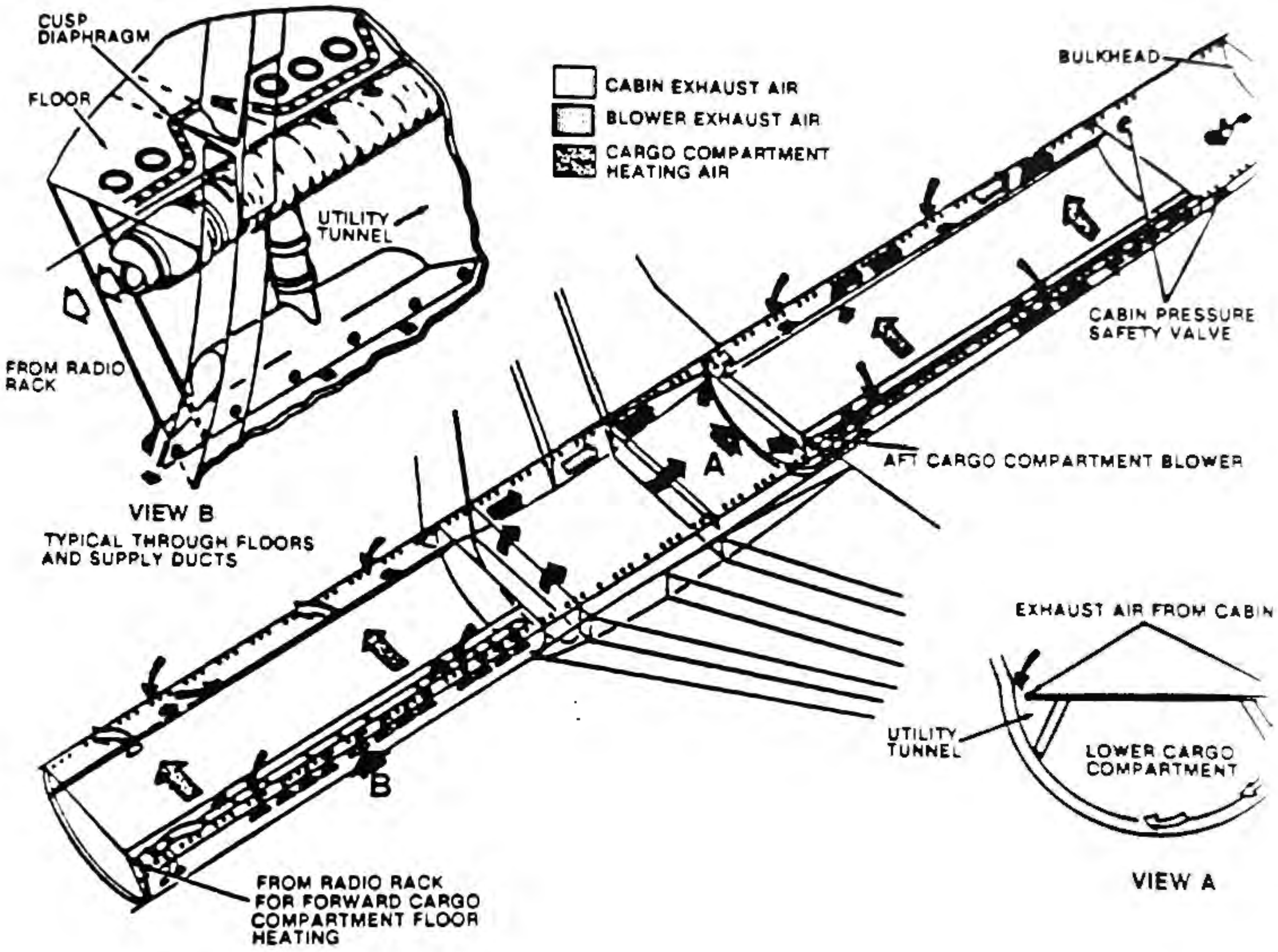
(3) The floor heating panels are in operation whenever the airplane electrical load buses are energized and the cockpit floor heater circuit breakers are closed.



TYPICAL FLIGHT COMPARTMENT CONDITIONED AIR DISTRIBUTION

FTX80343

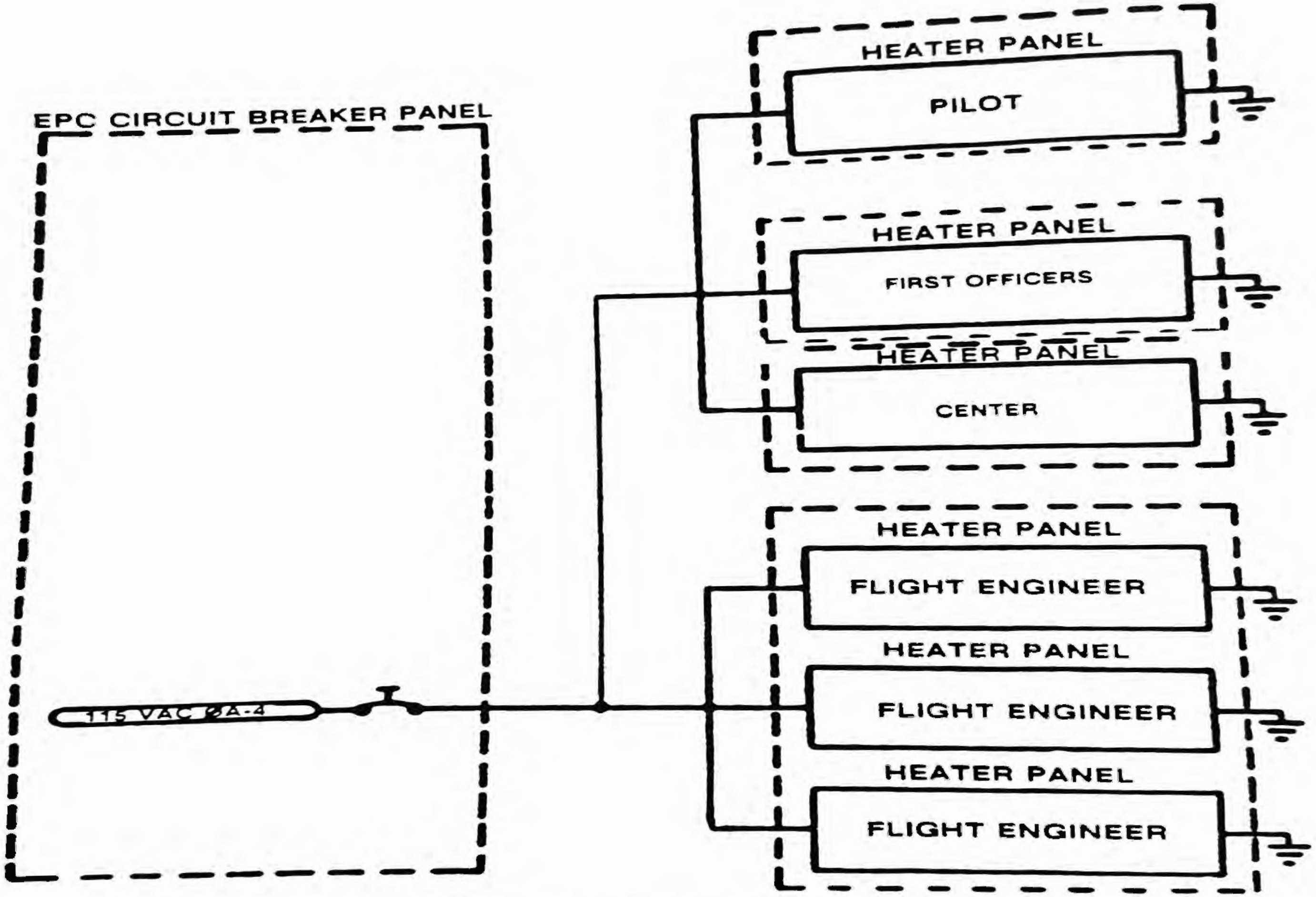
Figure 21-36


CUSP DIAPHRAGM
FLOOR
UTILITY TUNNEL
FROM RADIO RACK
VIEW B
TYPICAL THROUGH FLOORS AND SUPPLY DUCTS
CABIN EXHAUST AIR
BLOWER EXHAUST AIR
CARGO COMPARTMENT HEATING AIR
BULKHEAD
CABIN PRESSURE SAFETY VALVE
A
AFT CARGO COMPARTMENT BLOWER
B
FROM RADIO RACK FOR FORWARD CARGO COMPARTMENT FLOOR HEATING
EXHAUST AIR FROM CABIN
UTILITY TUNNEL
LOWER CARGO COMPARTMENT
VIEW A

CABIN EXHAUST AIR PROVISIONS

FTX80344

Figure 21-37



FLIGHT COMPARTMENT FLOOR HEATER PANELS
ELECTRICAL SCHEMATIC

FTX80352

Figure 21-38

7. Electric Heating System - Description and Operation

A. Introduction

(1) The major components of the heating system consist of an electric heater assembly, control panel, two temperature sensors, and required circuitry.

(2) The heater supplies heat to the cockpit compartment only (Figure 21-39). The heater is designed to operate on the ground only, using either external power or power supplied from the engine generators. Power is provided to the heater through a series of interlocks which will remove power from the heater if an overheat occurs, if the left hand recirculating fan is selected "OFF", or if the aircraft leaves the ground (Right Ground Control Relay Circuit Breaker) with the heater selected "ON".

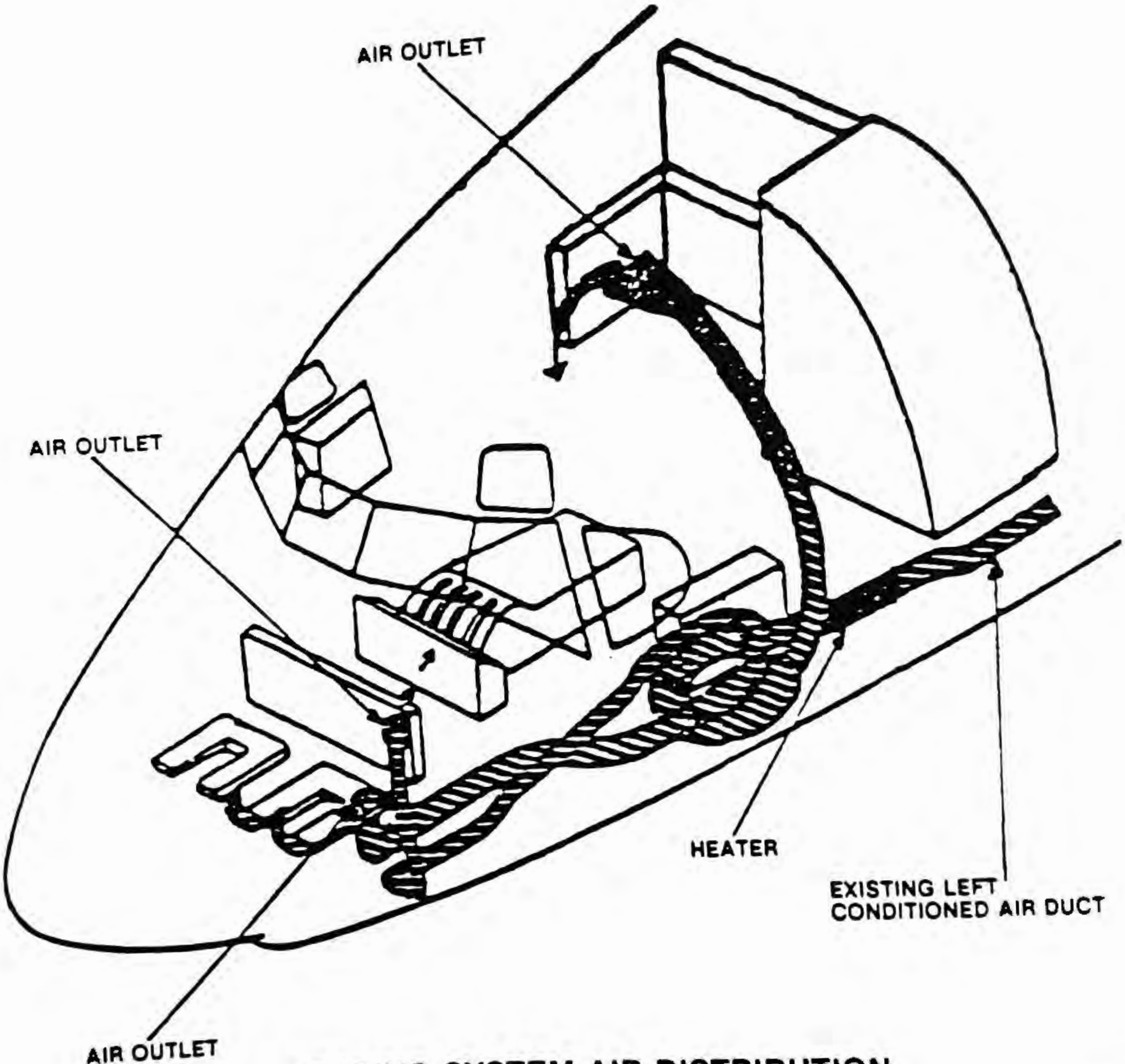
B. Description of Basic Components

(1) Electric Heater

The electric heater is located in the left conditioned air duct, under cockpit floor panels 677 and 680. The heater contains six heating elements, two element surface overtemperature switches, one duct air overtemperature switch and an electrical connector (Figure 21-40).

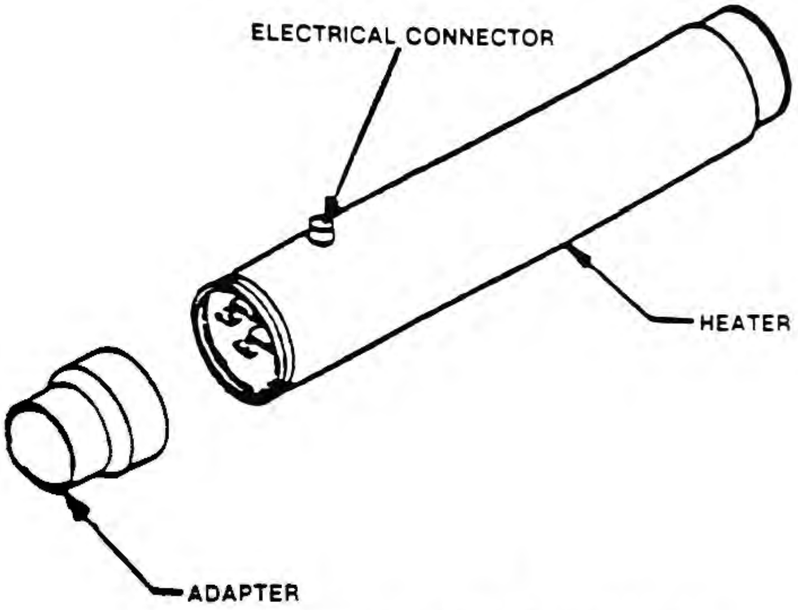
(2) Heater Element Surface Overtemperature Switches

The two heater element surface overtemperature switches located inside the heater are miniature snap action, disc type switches in hermetically sealed cases, factory adjusted to open a heater control circuit when the element temperature reaches 350°F ±15°F and close at 300°F ±15°F, at the location point where the switch is mounted on the heater element.



HEATING SYSTEM AIR DISTRIBUTION

Figure 21-39



ELECTRIC HEATER ASSEMBLY

FTX80354

Figure 21-40

(3) Duct Air Overtemperature Switch

The duct air overtemperature switch is located near the discharge end of the heater. It is the same as the heater element surface overtemperature switches, except that it is factory adjusted to open a separate control circuit when the average mass temperature of discharge air reaches 185°F ±10°F and close at 165°F ±5°F.

NOTE: **The duct air overtemperature switch and the heater element overtemperature switches are all electrically connected in series. If any one switch opens due to overtemperature the heater circuit will de-energize.**

C. Temperature Sensors

Two temperature sensors are located on the upper right flight Engineer's Panel adjacent to the heater control switch. The temperature sensors control the high (75°F - 85°F) and low (55°F - 65°F) cockpit temperature (Figure 21-41).

D. Relays

A ground control relay and a heater power relay are located on the EPC, Forward Equipment Panel. A heater control relay is located on the EPC, Aft Equipment Panel.

E. Operating Controls

The function of the heating system operating controls are as follows: (Ref DC8 wiring Diagram Manual, ATA 21 and 32).

(1) Heater Control Switch

The heater control switch is located on the upper right flight engineer's panel (Figure 21-41). The heater control switch is a three position switch (OFF, HIGH and LOW) used to operate the heater system. The switch is normally open ("OFF" position). When the switch is placed in the "LOW" position the heater should operate and the heater "ON" light should illuminate. The "LOW" temperature sensor controls cockpit temperature in this position. When the switch is placed in the "HIGH" position the heater should operate and the heater "ON" light should illuminate. The "HIGH" temperature sensor controls cockpit temperature in this position. When the switch is placed back into the "OFF" position the heater is deactivated.

(2) Heater "ON" light (Blue)

The heater "ON" light (Press-To-Test) is located just above the heater control switch on the upper right flight engineer's panel (Figure 21-41). Power comes from the supplemental heater control circuit breaker on the 28 vdc radio bus #3.

8. Cooling - Description and Operation

A. General

The cooling components of this airplane have been segregated into 4 main groups for coherent description of equipment and system operation. The four groups are the refrigeration system, refrigeration indication, radio rack cooling, and air conditioning heat exchanger exhaust flap control.

B. Description

(1) The actual cooling function of the conditioned air supplied to the occupied areas of the airplane is performed by the refrigeration systems, one for each air conditioning system. The refrigeration system utilizes a high density, low boiling point refrigerant which enables the use of a very small centrifugal compressor, and practically eliminates the possibility of air or moisture leaking into the system. Mechanical controls adjust the operating speeds of the compressor to the demands for cooling. Electrical controls function to start and stop the system, and control the condenser flap position to maintain condensing temperatures. Under most operating conditions, minimum cooling air and pneumatic supply air are demanded therefore minimum penalty is imposed on the airplane performance.

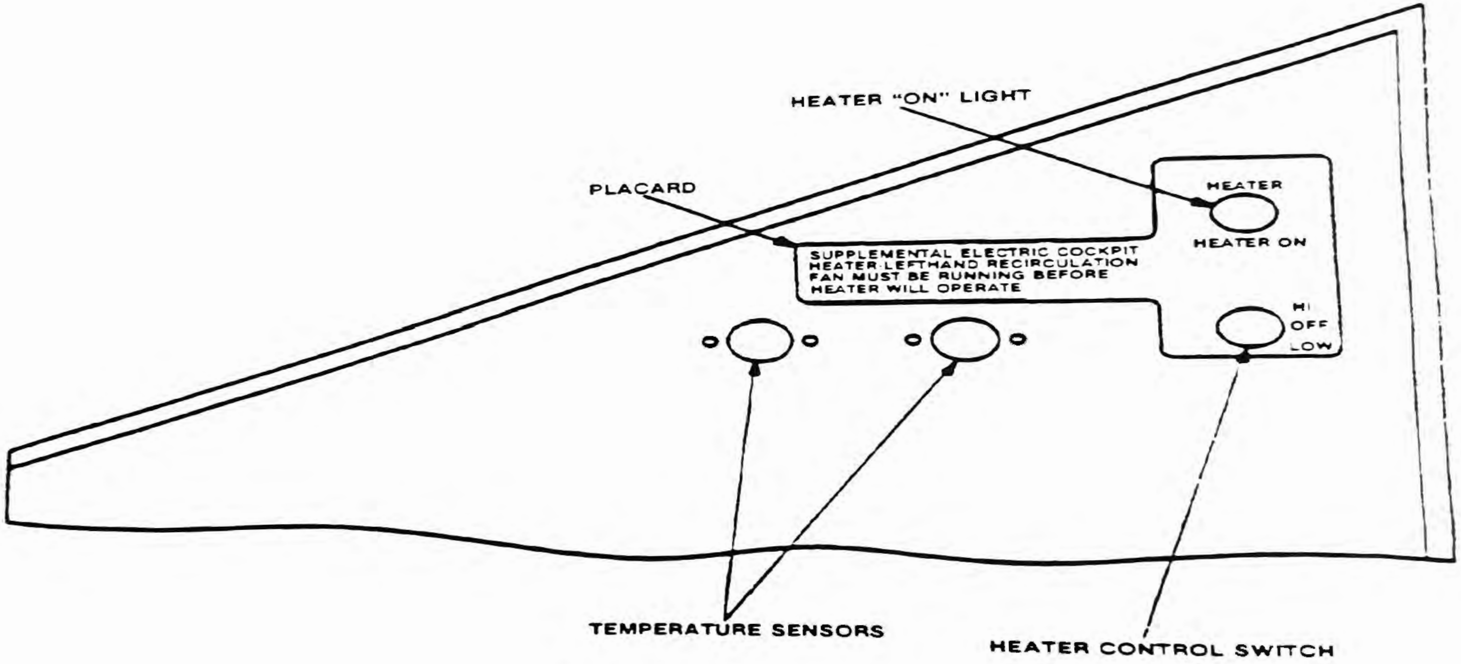
(2) Refrigeration indication components are not a related function of refrigeration system control but indicate temperatures in the refrigerant evaporator. These indications inform the operator of normal or abnormal operation.

(3) The radio rack cooling system uses flight compartment exhaust air to cool the electrical and electronic equipment, and heat the forward cargo compartment.

(2) Refrigerant Turbine Speed-Modulating Valve (Figure 21-44)

(a) The refrigerant turbine speed-modulating valve is an electrically controlled, pneumatically actuated, butterfly-type valve installed in the pneumatic supply line between the refrigerant turbine shutoff valve and the refrigerant compressor. The valve contains a filter, a spring-loaded pressure regulator, a solenoid connected by linkage to a poppet type control valve, a diaphragm-type control piston connected by a linkage to the butterfly shaft, and a nonlinear viscous damper also connected to the butterfly shaft.

(b) When the turbine shutoff valve is open, engine bleed air flows to the closed speed-modulating valve. A sensing line, terminating in the valve barrel upstream from the valve butterfly, ports some of this pressure through a filter to the spring-loaded pressure regulator. The regulator relieves pressure in excess of 12 to 14 pounds. The remaining pressure is ported to the poppet-type control valve and to the top side of the diaphragm-type control piston. The amount of pressure available to force the control piston downward is dependent upon the position of the control valve, which is controlled through linkage by the solenoid. Response of the solenoid to the signal received from the refrigeration system controller causes the control valve to open or close. The downward movement of the control piston and consequent opening of the butterfly are resisted by the force of the piston spring and the damper attached to the butterfly shaft. The damper, consisting of pairs of rotors and stators in a chamber filled with highly viscous liquid, retards the movement of the butterfly and prevents overtravel of the valve.


HEATER "ON" LIGHT
PLACARD
HEATER
HEATER ON
SUPPLEMENTAL ELECTRIC COCKPIT HEATER-LEFTHAND RECIRCULATION FAN MUST BE RUNNING BEFORE HEATER WILL OPERATE
HI
OFF
LOW
TEMPERATURE SENSORS
HEATER CONTROL SWITCH

HEATER CONTROL PANEL

FTX80355

Figure 21-41

(4) Partial cooling of the cabin compressor hot air supply, for delivery to the air conditioning mixing valve warm air port, is performed by the air conditioning heat exchanger exhaust flap control. The flap control operates in conjunction with the air conditioning mixing valve, which in turn is positioned by the demands of the temperature control system.

9. Refrigeration System - Description and Operation

A. General

(1) A vapor-cycle refrigeration system is installed in the airplane to supplement air-conditioning cooling in flight and provide total cooling while on the ground. The refrigeration system provides cooling for the flight compartment. Two distinct operational functions take place in the refrigeration system (Figure 21-42). One is the mechanical function of the refrigeration cycle, and the other is the electrical control function which controls and monitors system operations.

(2) The refrigeration cycle performs the cooling and dehumidification process upon air from the cabin compressors or recirculating fans. In this type of system, heat is removed from the air by evaporation of refrigerant 12 at low pressure. The refrigerant is then compressed to a higher pressure and delivered to the refrigerant condenser. The heat absorbed by the refrigerant in the evaporator and the compressor is transferred to cooling air passing through the refrigerant condenser. The condensed refrigerant 12 is then returned to the receiver-dryer and evaporator, completing the cycle.

(3) The refrigeration electrical control function protects refrigeration cycle operation by reacting to condenser overtemperatures, refrigerant compressor overspeeds or underspeeds, and oil pressure and temperature requirements. The system ensures that cooling air for the refrigerant condenser is provided from either ram air during flight or condenser fan air when on the ground. The amount of ram air passing over the condenser is controlled according to system demands. The control function also maintains sufficient cooling air to the flight and cabin compartment by utilizing the refrigeration cycle when necessary and shutting down the refrigeration cycle when sufficient cooling is available from ram air only. Ram air cooling depends on airplane altitudes, speed, and ambient temperatures, and is controlled by regulating the air-conditioning heat exchanger flap position. The cabin compressors

and heat exchangers provide hot and warm air for air-conditioning needs. The temperature control system mixes the hot, warm, and cold air available, and the air-conditioning mixing valve shuts down the refrigeration system when refrigeration is not required. When warm air supply gets too high for comfort, the refrigeration system begins operating.

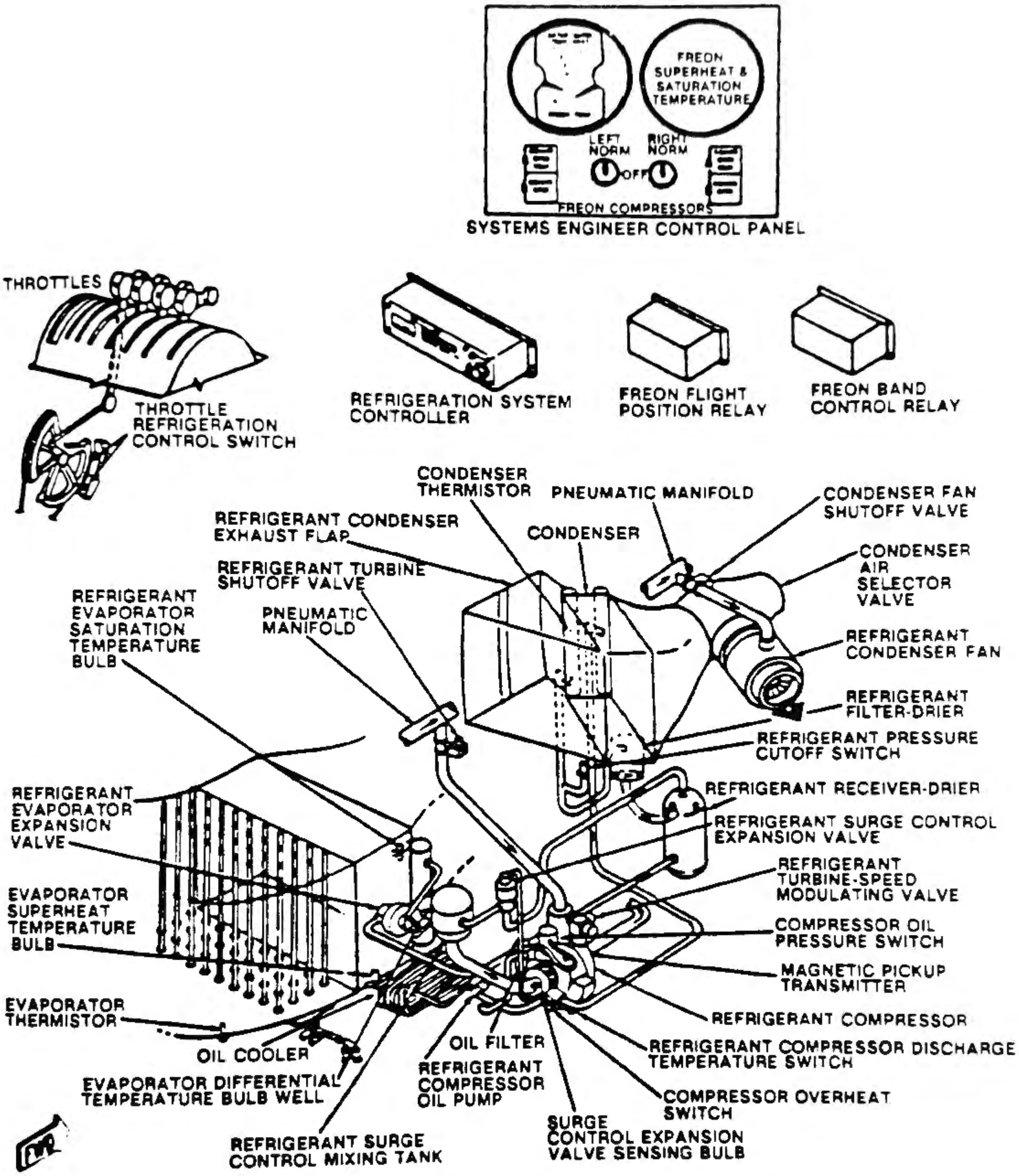
B. Component Description

(1) Refrigerant Compressor (Figure 21-43)

(a) A pneumatically driven refrigerant compressor located in the air-conditioning accessory compartment, is provided in the refrigeration system is raise low-temperature and low-pressure refrigerant vapor received from the evaporator to a higher pressure for delivery to the refrigerant condensor.

(b) Each unit consists of a pneumatic turbine connected to a centrifugal compressor by a common shaft and bearing assembly. An oil sump is incorporated in the compressor housing, and a sight glass is provided so that the compressor oil level may be observed. Oil inlet and outlet ports allow oil to be circulated from a separate oil pump. A refrigerant compressor oil overheat switch is installed in the oil sump to indicate when the temperature of the compressor oil exceeds 255° (±10°)F (124°(±5.5)C). A contact seal at the compressor end, and a segmented seal at the turbine end assures that oil is contained in the compressor housing and refrigerant is contained in the refrigerant system.

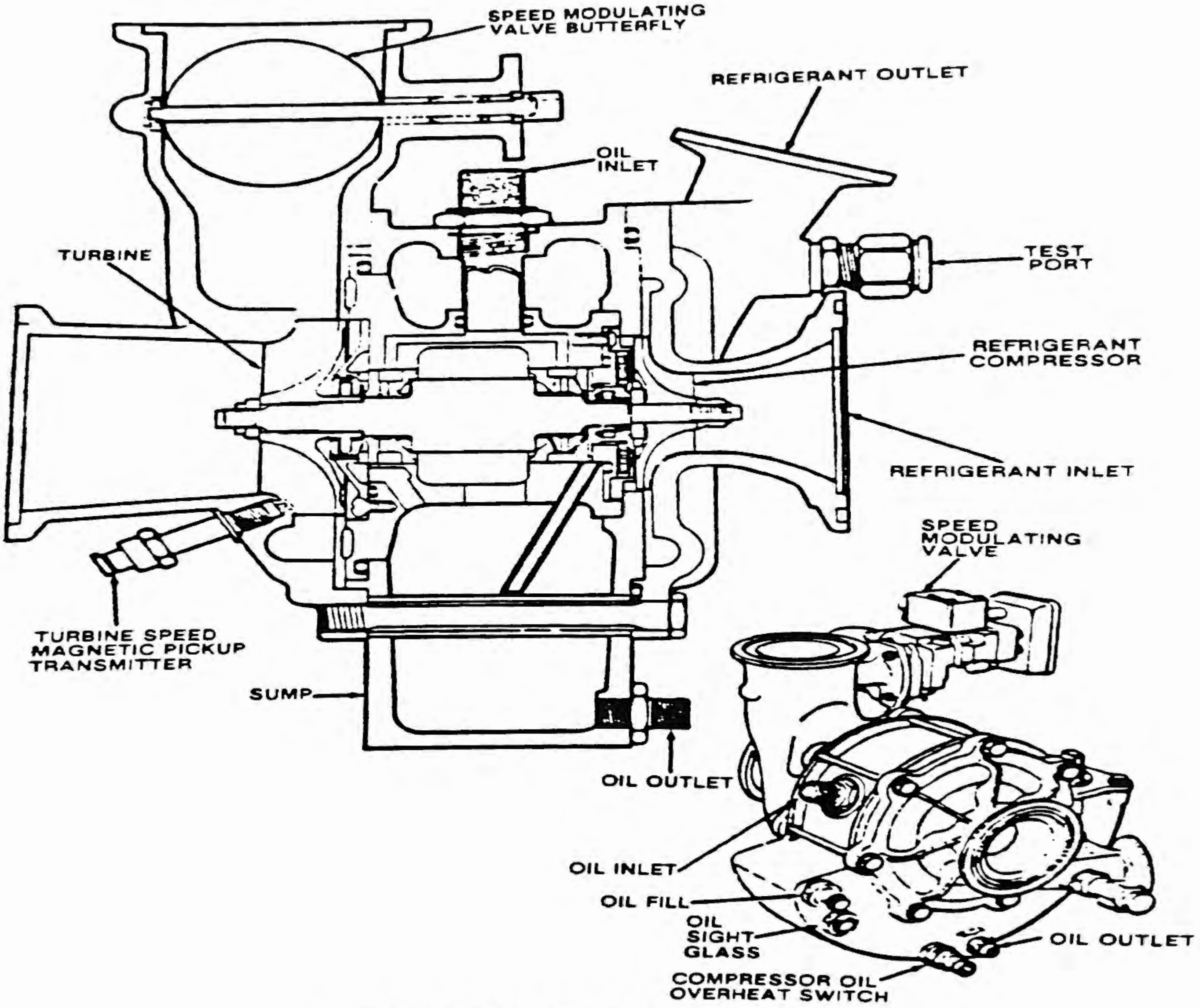
(c) The cooling capability of the refrigeration system varies directly with the speed of the compressor. Compressor speed is controlled by the turbine speed-modulating valve in response to signals received from the refrigeration system controller. Overspeed and underspeed protection is provided by the turbine-speed magnetic pickup transmitter, in conjunction with the refrigeration system controller.


FREON SUPERHEAT & SATURATION TEMPERATURE
LEFT NORM
RIGHT NORM
OFF
FREON COMPRESSORS
SYSTEMS ENGINEER CONTROL PANEL
THROTTLES
THROTTLE REFRIGERATION CONTROL SWITCH
REFRIGERATION SYSTEM CONTROLLER
FREON FLIGHT POSITION RELAY
FREON BAND CONTROL RELAY
CONDENSER THERMISTOR
PNEUMATIC MANIFOLD
CONDENSER FAN SHUTOFF VALVE
REFRIGERANT CONDENSER EXHAUST FLAP
CONDENSER
CONDENSER AIR SELECTOR VALVE
REFRIGERANT TURBINE SHUTOFF VALVE
REFRIGERANT EVAPORATOR SATURATION TEMPERATURE BULB
PNEUMATIC MANIFOLD
REFRIGERANT CONDENSER FAN
REFRIGERANT FILTER-DRIER
REFRIGERANT PRESSURE CUTOFF SWITCH
REFRIGERANT RECEIVER-DRIER
REFRIGERANT EVAPORATOR EXPANSION VALVE
REFRIGERANT SURGE CONTROL EXPANSION VALVE
REFRIGERANT TURBINE-SPEED MODULATING VALVE
EVAPORATOR SUPERHEAT TEMPERATURE BULB
COMPRESSOR OIL PRESSURE SWITCH
MAGNETIC PICKUP TRANSMITTER
EVAPORATOR THERMISTOR
REFRIGERANT COMPRESSOR
OIL FILTER
REFRIGERANT COMPRESSOR DISCHARGE TEMPERATURE SWITCH
OIL COOLER
REFRIGERANT COMPRESSOR OIL PUMP
EVAPORATOR DIFFERENTIAL TEMPERATURE BULB WELL
COMPRESSOR OVERHEAT SWITCH
SURGE CONTROL EXPANSION VALVE SENSING BULB
REFRIGERANT SURGE CONTROL MIXING TANK
FWD

REFRIGERATION SYSTEM COMPONENTS

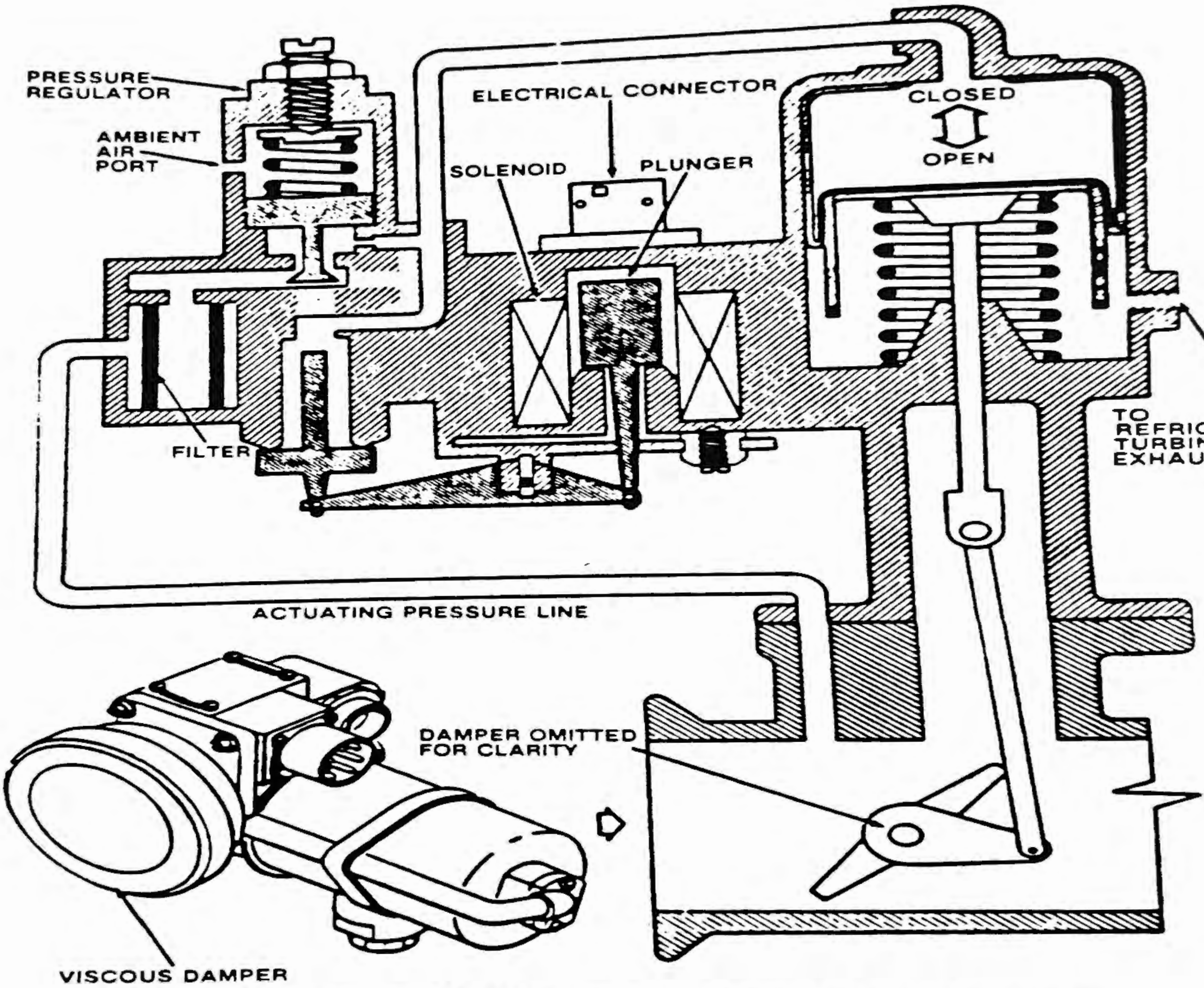
FTX80356

Figure 21-42



REFRIGERANT COMPRESSOR

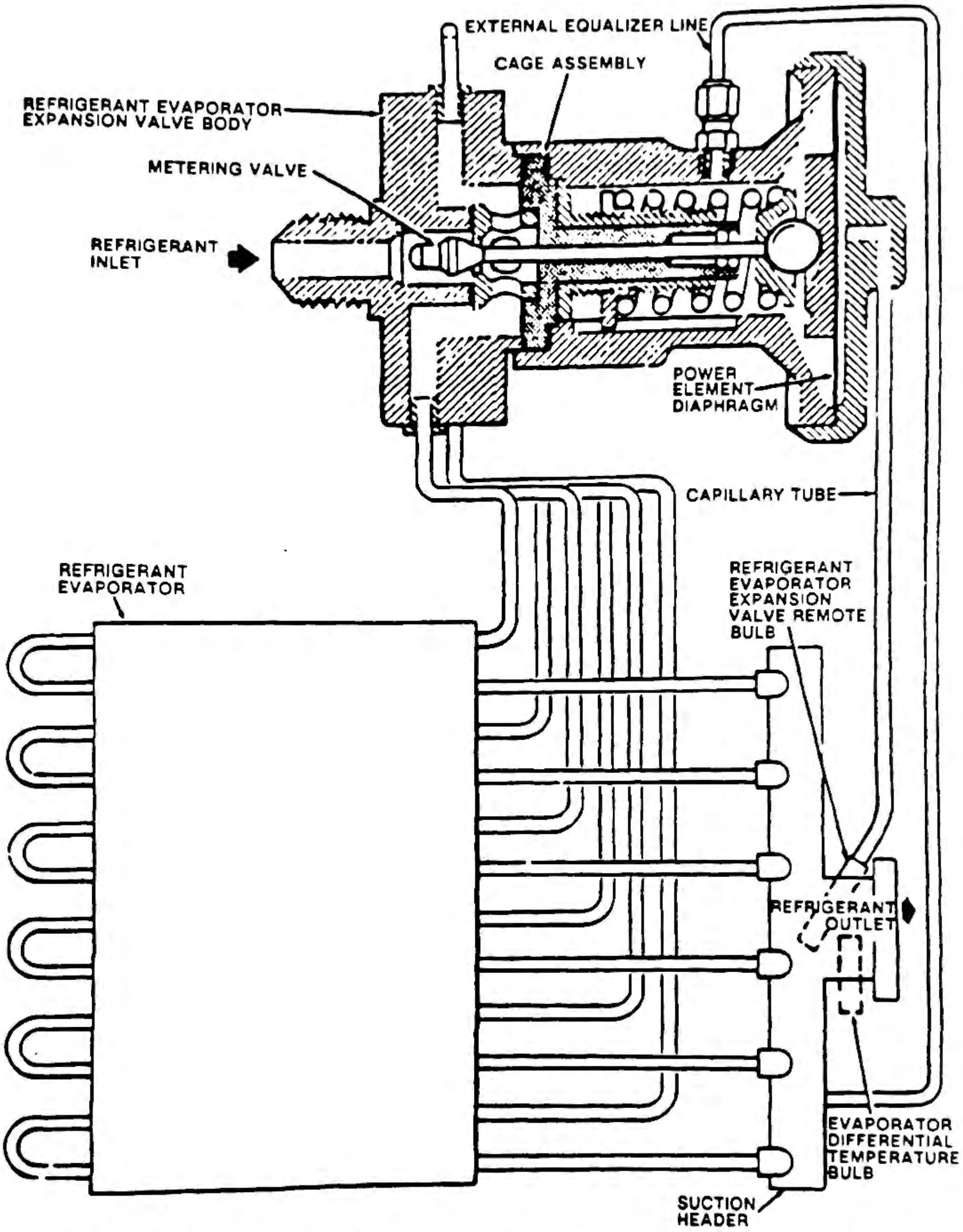
Figure 21-43



REFRIGERANT TURBINE SPEED-MODULATING VALVE

FTX80358

Figure 21-44



REFRIGERANT EVAPORATOR AND EVAPORATOR EXPANSION VALVE

FTX80361

Figure 21-47

(3) Refrigerant Turbine Speed Magnetic Pickup Transmitter

Each refrigerant compressor contains a magnetic pickup transmitter (Figure 21-43), installed in the scroll of the turbine, which supplies variable frequency signals that depend upon speed. Each unit is hermetically sealed and consists of a coil wound around a permanent magnet, with the leads of the coil connected to an electrical receptacle. The coil and permanent magnet are located near the turbine impeller. As each blade passes the coil, the flux density of the permanent magnet is increased and decreased, inducing a low lever signal in the coil. The 12 blades on the impeller produce 12 pulses in the transmitter for each revolution; therefore, the frequency of the signal from the transmitter is directly related to rpm.

(4) Refrigerant Compressor Discharge Temperature Switch

A refrigerant compressor discharge temperature switch is installed in the refrigerant discharge elbow of each compressor. The switch is normally closed and is connected in series with the compressor starting circuits. If the refrigerant discharge temperature becomes excessive, the switch opens to interrupt power to the controller, causing the system to shut down.

(5) Refrigerant Compressor Oil Pump

A 115-vac, motor-driven, refrigerant compressor oil pump is provided for each refrigeration system. The pump circulates oil from the compressor sump through a filter and the oil cooler which is located forward of the compressor. Oil under pressure is directed to the bearings and seals of the refrigerant compressor and drains into the compressor sump. A delay relay is incorporated in the pump electrical circuits to ensure continued oil pump operation for a period of 40 to 70 seconds after the refrigerant compressor has been shut down.

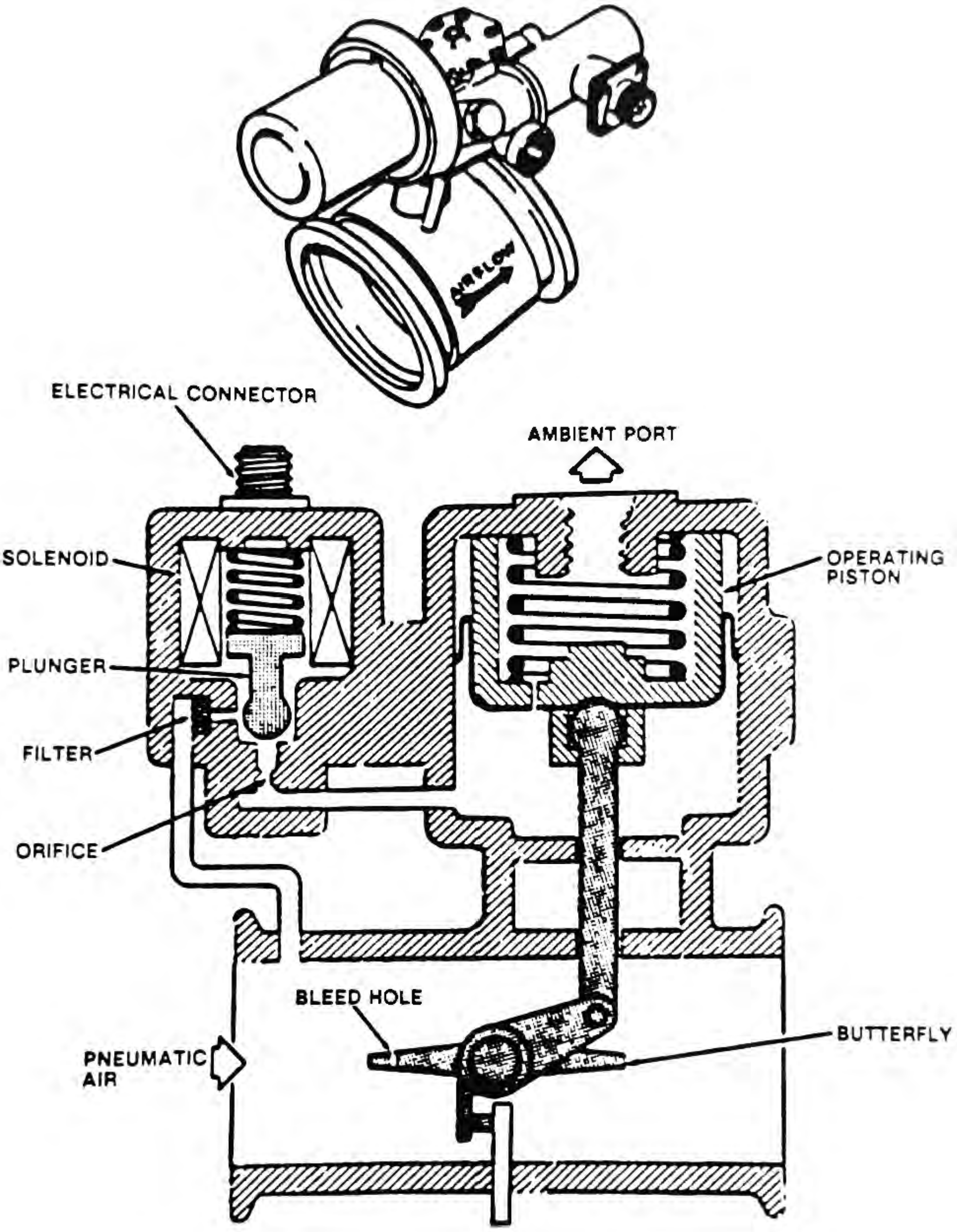
(6) Refrigerant Compressor Oil Pump Pressure Switch

The refrigerant compressor oil pump pressure switch located on the refrigerant compressor, is connected to the discharge line of the compressor oil pump. The pressure switch contacts close when oil pressure reaches 45 psig and open when oil pressure drops below 25 psig. The switch is connected in series with the refrigeration system controller power supply to ensure that the refrigeration system does not operate with insufficient oil pressure.

(7) Refrigerant Turbine Shutoff Valve (Figure 21-45)

(a) The refrigerant turbine shutoff valve is an electrically controlled, pneumatically operated valve which starts and stops the refrigerant compressor by controlling the supply of pneumatic air to the turbine. The valve is located in the duct from the pneumatic manifold to the refrigerant compressor in the air-conditioning accessory compartment. The valve consists of a 2-position solenoid valve and a pneumatically operated butterfly assembly.

(b) When the solenoid is deenergized, the spring-loaded operating piston maintains the butterfly valve in the closed position. When the solenoid is energized, upstream pneumatic pressure is allowed to flow past the plunger valve seat, through the orifice, and to the lower chamber of the pneumatic actuator, allowing the butterfly valve to open slowly. When the solenoid is deenergized, the plunger closes off pressure supply to the lower chamber and the pressure in the chamber is slowly bled to ambient through the orifice in the piston head, allowing the butterfly to close.



REFRIGERANT TURBINE SHUTOFF VALVE

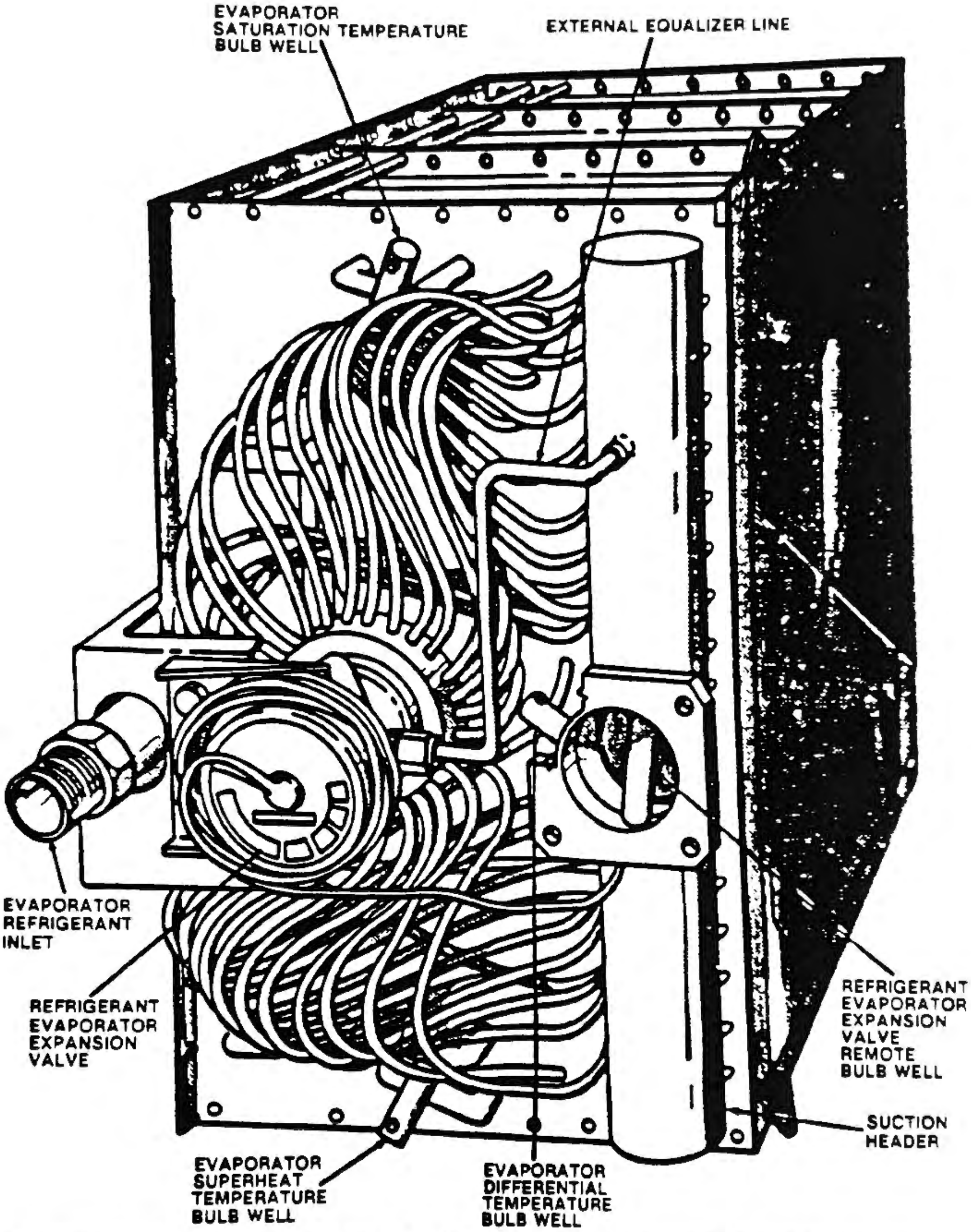
FTX80359

Figure 21-45

(8) Refrigerant Evaporator (Figure 21-46)

(a) The refrigerant evaporator is a direct-expansion-type unit and incorporates a 12-row plate fin and tube aluminum coil. The coil is fed from an expansion valve through an integral distributor, which feeds liquid refrigerant through 30 distributing tubes. The purpose of the unit is to absorb heat from ventilating air being delivered to the passenger and flight compartments. One unit is installed in each refrigeration system and is located in the air-conditioning accessory compartment. The evaporator incorporates provisions for installing the saturation temperature and superheat temperature bulbs. Two wells are brazed to return bends above and below the expansion valve and are centrally located near the top and bottom of the evaporator. With this arrangement, the evaporator can be used in either the left or right system. The saturation temperature bulb is installed in the upper well, and the superheat temperature bulb is installed in the lower well. A third well is brazed to the suction header outlet and houses the differential temperature bulb. The expansion valve remote bulb well is adjacent to the differential bulb well and extends completely through the suction header.

(b) In operation, the high-pressure liquid refrigerant is injected into 30 tubular circuits by the expansion valve. Upon entering the tubular circuits, the pressure decreases. This action cools the remaining liquid to the saturation temperature corresponding to the pressure in the evaporator. As this temperature is colder than the temperature of the air passing through the coil, heat flows from the air to the refrigerant. Before the refrigerant has completely passed through the coils to the suction header, all the liquid has evaporated. The gas passing through the coils picks up additional heat from the air and becomes superheated. Control of refrigerant flow to produce the desired amount of superheat is performed by the expansion valve.


EVAPORATOR SATURATION TEMPERATURE BULB WELL
EXTERNAL EQUALIZER LINE
EVAPORATOR REFRIGERANT INLET
REFRIGERANT EVAPORATOR EXPANSION VALVE
REFRIGERANT EVAPORATOR EXPANSION VALVE REMOTE BULB WELL
SUCTION HEADER
EVAPORATOR SUPERHEAT TEMPERATURE BULB WELL
EVAPORATOR DIFFERENTIAL TEMPERATURE BULB WELL

REFRIGERANT EVAPORATOR AND EVAPORATOR EXPANSION VALVE

FTX80360

Figure 21-46

(9) Refrigerant Evaporator Expansion Valve (Figure 21-46)

(a) The refrigerant evaporator expansion valve is designed to meter the correct amount of liquid to the evaporator and to divide the liquid equally among the evaporator coils. One diaphragm-operated, pressure sensing-type, expansion valve is located on the evaporator of each refrigeration system. The valve incorporates an inlet and outlet port and two pressure-sensing ports (Figure 21-47). A distributor interconnects the outlet port of the expansion valve to the evaporator. Internally, the valve contains a power element diaphragm and a spring-loaded metering valve.

(b) Control is achieved by sensing the amount of superheat in the suction header of the evaporator. When the correct amount of liquid refrigerant is being metered, all the liquid is evaporated and the temperature of the gas in the suction header is a few degrees above the evaporating temperature. The purpose of the temperature increase is to ensure that no liquid refrigerant enters the compressor. In operation, the amount of superheat varies from approximately 0° to 20°F (0° to 11.1°C). Controlling the expansion valve prevents any liquid refrigerant from entering the compressor and assures that practically all the evaporator surface is actively evaporating the refrigerant.

(c) The mechanism of the valve is controlled by refrigerant pressure acting on the power element diaphragm. One side of the diaphragm is connected by a capillary tube to the remote bulb mounted in the evaporator suction header. The bulb and capillary tube are filled with refrigerant 12. The refrigerant in the remote bulb creates a pressure which corresponds to the temperature of the gas in the suction header. Pressure created in the remote bulb acts on the power element diaphragm to move the valve toward the open position. If the remote bulb on the suction header is warm, the gas pressure inside the bulb is high causing the valve to open further, allowing more refrigerant to enter the evaporator. The increased refrigerant flow results in cooler gas leaving the evaporator which cools and reduces the gas pressure in the remote bulb. The diaphragm pressure is then reduced and the valve moves towards the closed position.

(d) An equalizer line interconnects the opposite side of the diaphragm with the suction header of the evaporator. The external equalizer line prevents the expansion valve from overfeeding liquid into the evaporator if the pressure in the evaporator suddenly rises. This can occur if the quantity of refrigerant being drawn away by the compressor is suddenly reduced. An increase in the suction header temperature and pressure results and is sensed by the expansion valve through the equalizer line. The pressure increase causes the power element diaphragm to reduce the metering valve opening. If the condition of the refrigerant leaving the evaporator is wet (not totally evaporated), the pressure generated by the remote bulb is exactly the same as the pressure inside the suction header. This pressure is sensed by the equalizer line and the power element diaphragm is balanced. However, the spring load against the metering valve is in the valve closed direction, which upsets the balance to close the valve. Since the remote bulb has a certain thermal lag, bulb temperature cannot be increased rapidly. A sudden rise in suction header pressure is sensed immediately on the valve closed side of the diaphragm, closing the valve to prevent overfeeding. Due to the increase in suction header temperature, the remote bulb pressure increases, moves the diaphragm to open the valve, and operates at a new equilibrium position.

(10) Refrigerant Surge Control Mixing Tank and Expansion Valve (Figure 21-48)

The refrigerant surge control expansion valve is designed to release high-pressure gas from the receiver-drier into the surge control mixing tank. The mechanism of the valve is controlled by pressure acting on the power element diaphragm. One side of the diaphragm is connected by a capillary tube to the remote temperature sensing bulb mounted in the compressor inlet elbow. The bulb and tube are filled with refrigerant 12 and refrigerant pressure in the bulb changes as the compressor inlet elbow temperature changes. The other side of the diaphragm is spring-loaded to keep the valve closed and is also internally vented to pressure in the mixing tank. The valve opens only if the refrigerant gas in the suction elbow has excessive superheat, which occurs if the compressor is operating in a surging or near-surging condition. During a surge cycle, some of the high-temperature discharge gas from the compressor flows backwards through the compressor to heat the valve bulb in the suction elbow. Excessive pressure develops on top of the diaphragm, causing the valve to open and admit high-pressure gas from the top of the receiver-drier to the mixing tank. Pressure is increased at the compressor inlet to stop the surging condition.

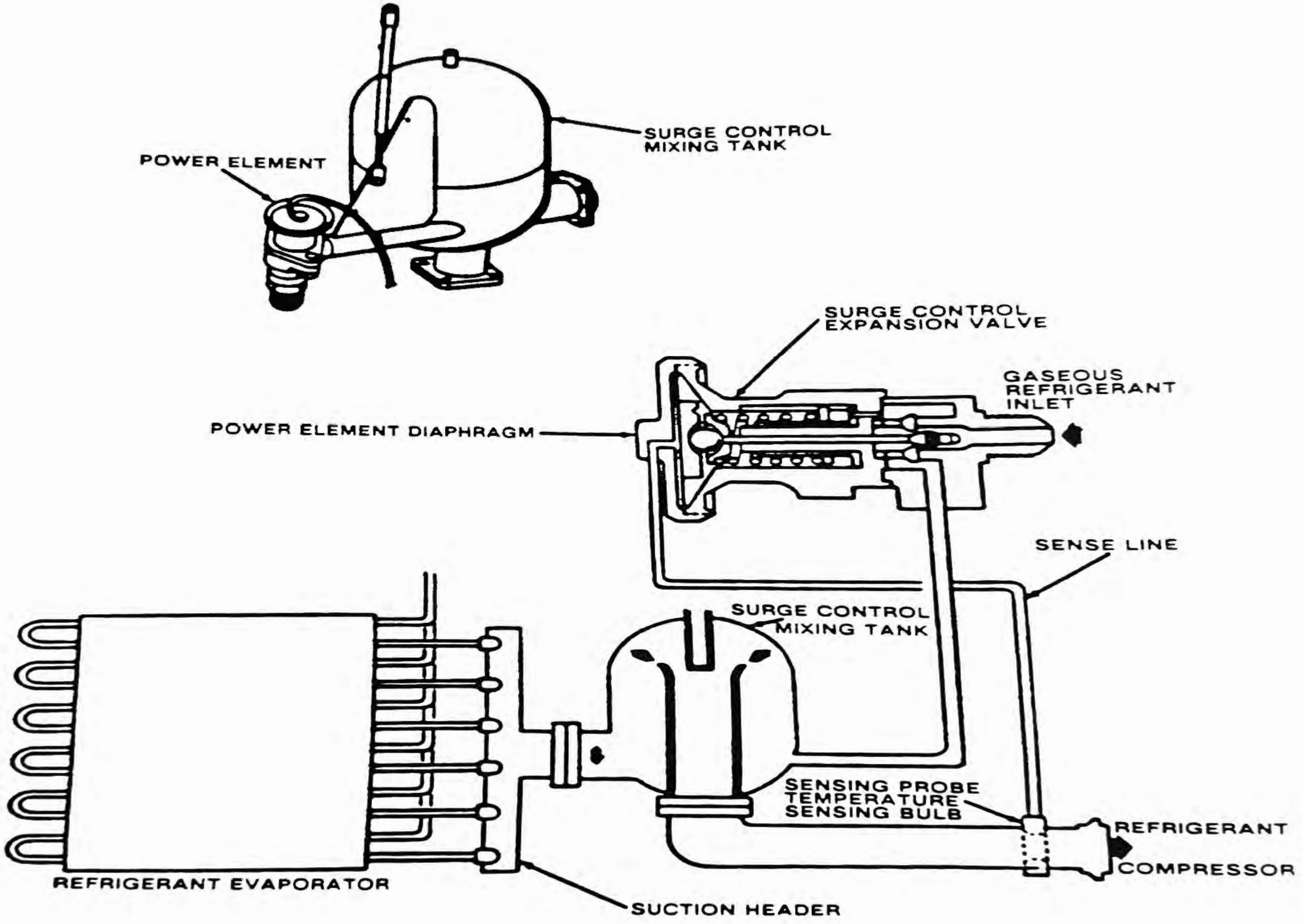
(11) Refrigerant Receiver-Drier (Figure 21-49)

(a) The refrigerant receiver-drier, located between the refrigerant condenser and evaporator, serves as a reservoir for liquid refrigerant during refrigeration system operation. A receiver-drier for each refrigeration system is mounted on the aft bulkhead of the air-conditioning accessory compartment. When charged, the receiver-drier contains dichlorodifluoromethane, which is designated by the refrigeration industry as refrigerant 12. This refrigerant is a colorless, odorless material having a boiling point at standard atmospheric pressure of -21.6°F (-30.7°C).

(b) The receiver-drier is equipped with an inlet port and two outlet ports which are fitted with quick-disconnect-type couplings. The upper side (inlet) port also includes an integral connection closed by a removable plug and safety head assembly, through which the filter-drier cartridge is installed. The purpose of the safety head is to discharge the receiver (and to discharge the system, if the receiver is installed in the airplane) in the event of excessive refrigerant pressure. All refrigerant flow into the receiver passes through the filter-drier to prevent the recirculation of contaminants in the refrigerant system. A rupture disc installed in the head bursts at 420-465 psig at 72°F (22.2°C). A liquid level indicator is installed on the filter-drier.

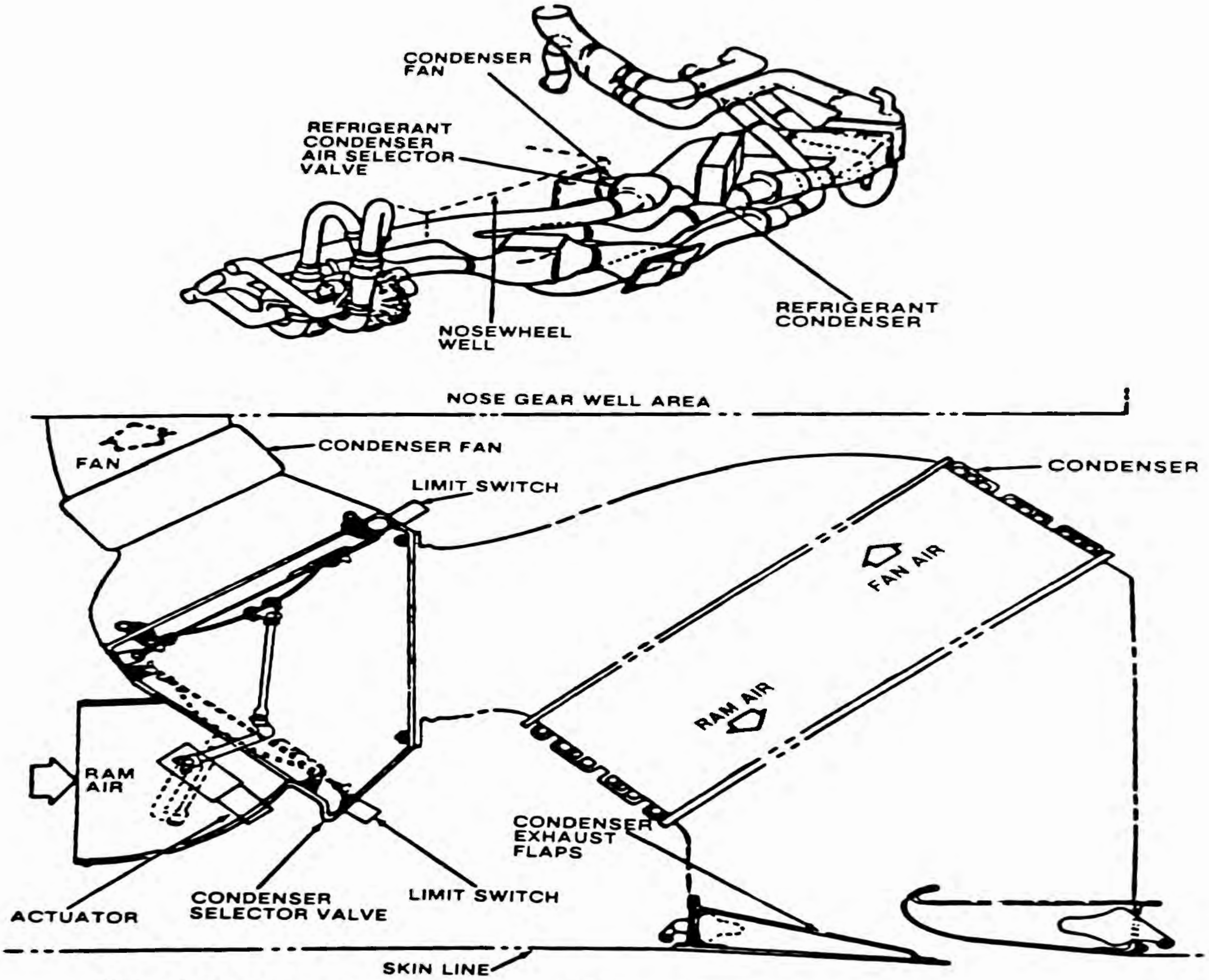
(12) Refrigerant Filter-Drier (Figure 21-50)

(a) An external filter-drier assembly is installed in each system between the condenser and the receiver-drier and is mounted adjacent to the receiver on the bulkhead of the air-conditioning accessory compartment. The filter is installed to prevent recirculation of contaminants through the system.


POWER ELEMENT
SURGE CONTROL MIXING TANK
SURGE CONTROL EXPANSION VALVE
GASEOUS REFRIGERANT INLET
POWER ELEMENT DIAPHRAGM
SENSE LINE
SURGE CONTROL MIXING TANK
SENSING PROBE TEMPERATURE SENSING BULB
REFRIGERANT
COMPRESSOR
REFRIGERANT EVAPORATOR
SUCTION HEADER

FTX80362

Figure 21-48



REFRIGERANT CONDENSER AIR SELECTOR VALVE

Figure 21-53

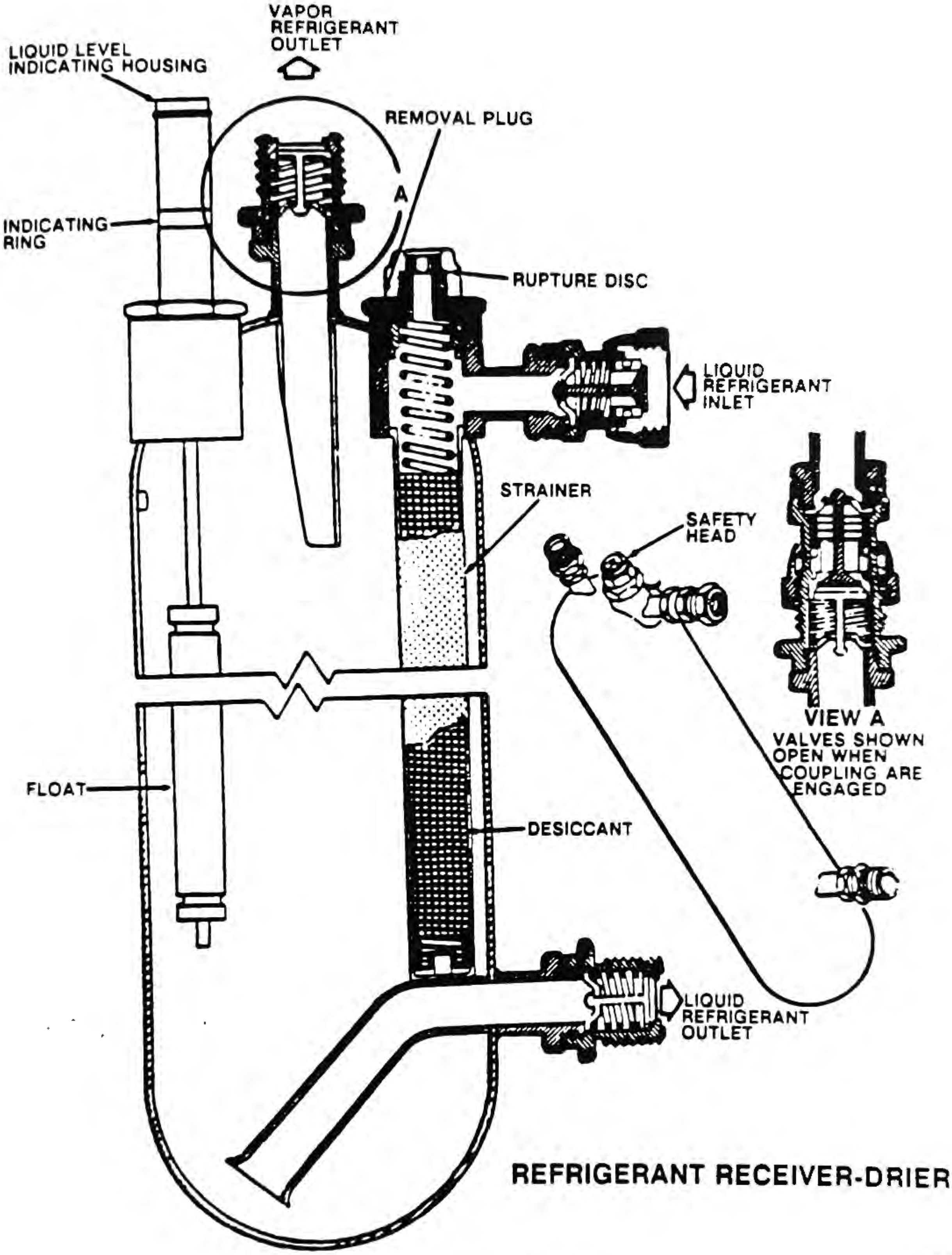
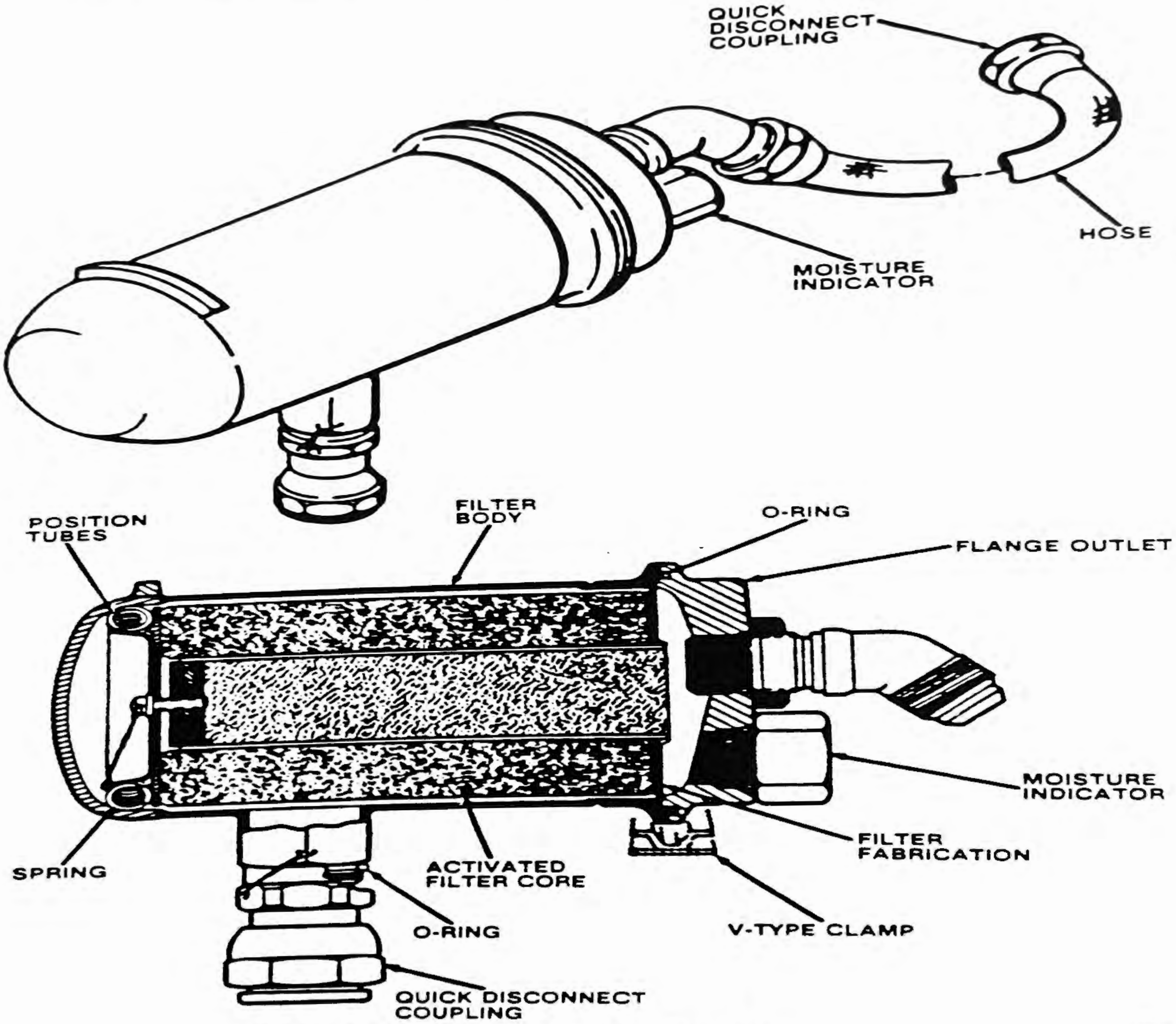

VAPOR REFRIGERANT OUTLET
LIQUID LEVEL INDICATING HOUSING
REMOVAL PLUG
A
INDICATING RING
RUPTURE DISC
LIQUID REFRIGERANT INLET
STRAINER
SAFETY HEAD
VIEW A
VALVES SHOWN OPEN WHEN COUPLING ARE ENGAGED
FLOAT
DESICCANT
LIQUID REFRIGERANT OUTLET
REFRIGERANT RECEIVER-DRIER
FTX80363

Figure 21-49



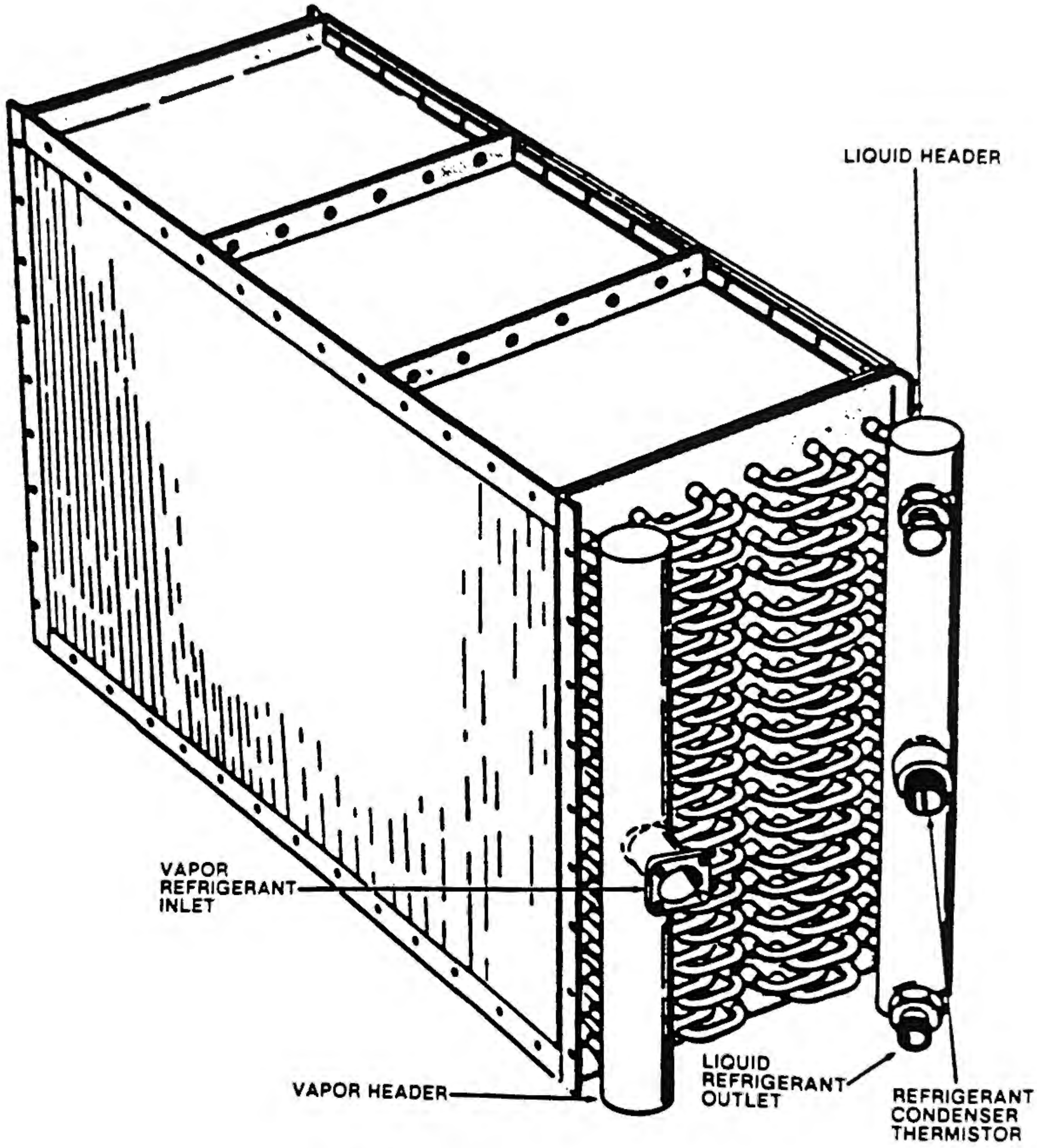
REFRIGERANT FILTER-DRIER
Figure 21-50

(b) The filter drier assembly consists of a body, an outlet flange, a throw-away-type activated core filter, and a V-type clamp that secures the outlet flange to the body. The filter body inlet port is equipped with a quick disconnect coupling and the outlet port in the outlet flange is equipped with a hose and quick disconnect coupling to provide for easy filter change without opening the refrigeration system. A moisture indicator is provided for visual observation of the filter condition while installed in the airplane. The moisture indicator dot is green when the filter is in a satisfactory condition.

(13) Refrigerant Condenser (Figure 21-51)

(a) The air cooled refrigerant condenser functions to change compressed superheated refrigerant 12 gas to a high-pressure liquid. The condenser located forward of the air conditioning accessory compartment pressure bulkhead. The condenser assembly, which is rectangular in shape, incorporates tubular coils that circulate refrigerant through the condenser. A vapor header is installed at the refrigerant inlet side and a liquid header at the outlet side. Cooling fins around the coil provide a greater heat transfer area.

(b) High-pressure, high-temperature gas flows from the compressor to the vapor header, and then through the coils of the condenser. Heat from the high-temperature gas is transferred from the coils to the cooling fins then to the cooling ram airflow in flight and to the condenser fan airflow on the ground. Refrigerant 12 gas is condensed to high-pressure liquid and collected in the liquid header. The liquid is returned to the receiver-drier to continue the refrigeration cycle.



REFRIGERANT CONDENSER

FTX80365

Figure 21-51

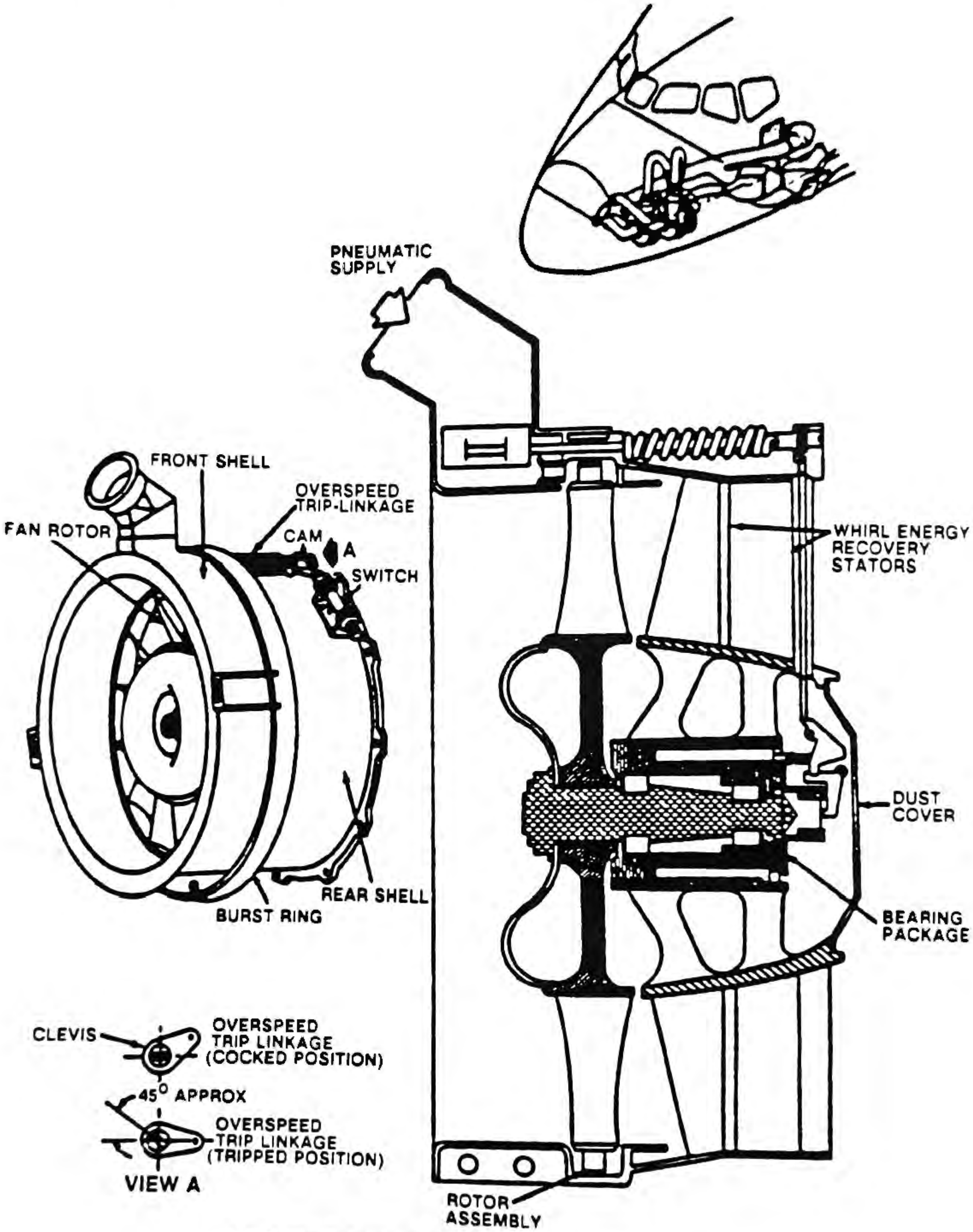
(14) Refrigerant Condenser Fan (Figure 21-52)

(a) A pneumatically driven, single-stage, axial flow-type refrigerant condenser fan is located in each refrigeration system, forward of the corresponding condenser. The fans provide cooling airflow through the condensers during refrigeration system operation when the airplane is on the ground. The fan assembly consists of the rear shell, balancing assembly, and front shell. The front shell contains an inlet elbow that houses the overspeed trip bleed air shutoff valve and turbine air nozzles. The front shell is designed to contain fragments resulting from a rotor burst as well as to serve as the inlet section of the fan. The rear shell contains two rows of stator blades which remove the whirl from the air as it leave the rotating blades. This recovers some of the whirl energy and improves the static efficiency of the unit.

(b) The overspeed trip unit is a mechanical trip-out device using the centrifugal force principle. The overspeed trip-out device, through a mechanical linkage, partially closes a valve in the condenser fan nozzle ring when the fan reaches a speed of approximately 13,000 rpm. The trip mechanism shuts down the fan by cutting off the pneumatic air supply. The overspeed trip unit must be manually reset after tripping. In addition, when the fan overspeed mechanism trips, a cam which is turned by the overspeed trip linkage operates a plunger actuated switch to cut off the refrigeration system. The fan is driven by air from the low-pressure pneumatic system. When the fan is operating at a normal speed of 10,500 rpm, air is drawn through the condenser at the rate of approximately 6900 cfm. Pneumatic supply air entering the nozzle ring passes through the multiple nozzles and drives the turbine blades, which are arranged in a ring surrounding the fan blade tips. Pneumatic supply air pressure driving the condenser fan exhausts into the nosewheel well area, along with the exhausted air which is being drawn across the condenser.

(15) Refrigerant Condenser Fan Shutoff Valve

The refrigerant condenser fan shutoff valve is an electrically controlled pneumatically operated valve used to start and stop the condenser fan. One valve is installed in each refrigeration system. The valve and solenoid unit is similar to the refrigerant turbine shutoff valve.



REFRIGERANT CONDENSER FAN

FTX80366

Figure 21-52

(b) High-pressure liquid refrigerant leaves the receiver (Figure 21-55) and flows to the refrigerant evaporator expansion valve. The expansion valve meters the correct amount of liquid refrigerant to the evaporator, and divides the refrigerant equally among the evaporated coils. The high-pressure liquid refrigerant flowing through the valve orifice is immediately reduced to the low pressure existing in the evaporator. Low pressure in the evaporator coils is continuously maintained by suction action of the refrigerant compressor. Liquid refrigerant evaporates at this low pressure, picking up heat in the process. Since the evaporator is installed between the warm air supply and cold air supply ducting (Figure 21-56), the latent heat of vaporization required to evaporate (boil off) the refrigerant is supplied by the higher temperature air passing over the evaporator coils. Liquid refrigerant passing through the refrigerant coils continues to absorb heat until completely evaporated to a gas.

(c) From the evaporator, refrigerant gas flows through the refrigerant surge control mixing tank to the suction side of the refrigerant compressor. The temperature of the gas passing over the expansion valve remote bulb and the pressure in the suction header (Figure 21-55), varies the pressure on the power element diaphragm in the evaporator expansion valve, to control the amount of refrigerant entering the evaporator. The warmer the temperature and/or the lower the pressure of the gas leaving the evaporator, the more liquid refrigerant allowed through the expansion valve. Conversely, the colder the temperature and/or the higher the pressure of the gas leaving the evaporator, the less liquid refrigerant allowed to enter the evaporator. The evaporating temperature depends on the pressure maintained in the evaporator by the suction of the refrigerant compressor.

(d) The surge control system functions only if the compressor is operating in a surging condition, that is, when the ratio of the compressor discharge pressure to the inlet pressure is too great for the operating speed. During surging, a portion of the high-temperature discharge gas flows backwards through the compressor to the suction elbow where the surge tank expansion valve bulb is installed. The expansion valve reacts to this higher than normal superheat condition (sensed by the bulb), causing the valve to open and admit high-pressure gas from the top of the receiver to the surge control mixing tank. Compressor inlet pres-

(16) Refrigerant Condenser Air Selector Valve (Figure 21-53)

(a) The refrigerant condenser air selector valve is a three port valve incorporating a single flapper, two limit switches, and an electrically operated actuator. One port of the valve is connected to the inlet air header of the condenser, adjacent to the nosewheel well. Another port of the valve is connected to the ram air ducting from the nose scoop.

(b) The third port of the valve is connected to the condenser fan which is connected to the nosewheel well by a shroud. The flapper is hinged to cover either the ram air inlet port or the condenser fan port. The limit switches prevent operation of the refrigeration system while the flapper is moving from one position to the other. On the ground, the flapper of the air selector valve is positioned over the ram air port, the condenser fan port is open, and one limit switch is closed. The fan operates to pull air through the condenser fan exhaust flaps, over the condenser, and exhaust air into the nosewheel well. In flight, the flapper of the air selector valve is positioned over the condenser fan port and the ram air port is open. Ram air flows from the nose scoops through the selector valve, over the condenser, and is vented overboard through the condenser exhaust flaps.

(17) Refrigerant Condenser Exhaust Flaps and Actuator

(a) The refrigerant condenser exhaust flap consists of two flaps mechanically linked together and controlled automatically by a linear actuator. On the ground the flaps serve as the condenser cooling air inlet, and in flight the flaps serve as the condenser air cooling outlet. Each installation consists of two flaps, hinged fore and aft, and linked together so that as the forward flap moves outboard, the aft flap move inboard.

(b) The refrigerant condenser exhaust flap actuator consists of an electrical motor, gear train, jackscrew, drive unit and control unit. The actuator converts electrical energy into mechanical linear movement. One end of the actuator housing contains a stationary mounting eye and the opposite end of the housing contains a tubular housing for the jackscrew and the drive unit. The fractional-horsepower, reversible-type motor is provided with a friction brake. Splines on the motor pinion engage a gear train that terminates in a spur gear on the drive unit. Principal components of the drive unit are a spur gear and a hollow cylindrical drive tube. The drive tube includes a mechanical stop internally, and a worm externally. The worm engages a gearshaft of the control unit and the drive tube engages the jackscrew. The control unit consists primarily of two gearshafts geared together, cams, and limit switches. The actuator is mounted adjacent to the condenser exhaust flap and is connected to the flap operating mechanism. When the motor is energized, the actuator either extends (flaps close) or retracts. Rotary motion is transmitted from the motor pinion, and through the gear train to the drive tube. Rotary motion of the drive tube causes the jackscrew to extend or retract. The jackscrew body is prevented from rotating by the anti-rotation tube.

(c) On the ground, with the refrigeration system operating, the flaps are automatically full open. The condenser fan draws ambient air in through the flaps and across the condenser. The air then flows through the fan-air side of the condenser air selector valve, across the fan, and exhausts into the nosewheel well (Figure 21-53). On the ground, with the refrigeration system off, the flaps are at the trail position. During flight with the refrigeration system operating, the position of the exhaust flap is regulated to provide cooling ram airflow across the condenser. Ram air passes through the condenser air selector valve, across the condenser, and is exhausted overboard through the exhaust flaps. Cooling airflow across the condenser and, therefore the condenser temperature, is controlled by the position of the exhaust flaps. The position of the exhaust flaps is regulated by the system controller. In flight, with the refrigeration system shut down, the flaps are in the trail position. This prevents a shock wave from affecting the passage of ram air into the fuselage nose air-conditioning scoop.

(18) Refrigeration System Controller (Figure 21-54)

The refrigeration system controller consists of electronic amplifiers, a voltage regulator, and relays. The major function of the controller is to maintain the temperature of the air leaving the evaporator at approximately 50°F (10°C). This is accomplished by controlling the speed of the refrigerant compressor. Compressor speed is controlled by regulating the position of the turbine speed modulating valve and controlling the position of the condenser exhaust flaps.

(19) Refrigerant Condenser Thermistor

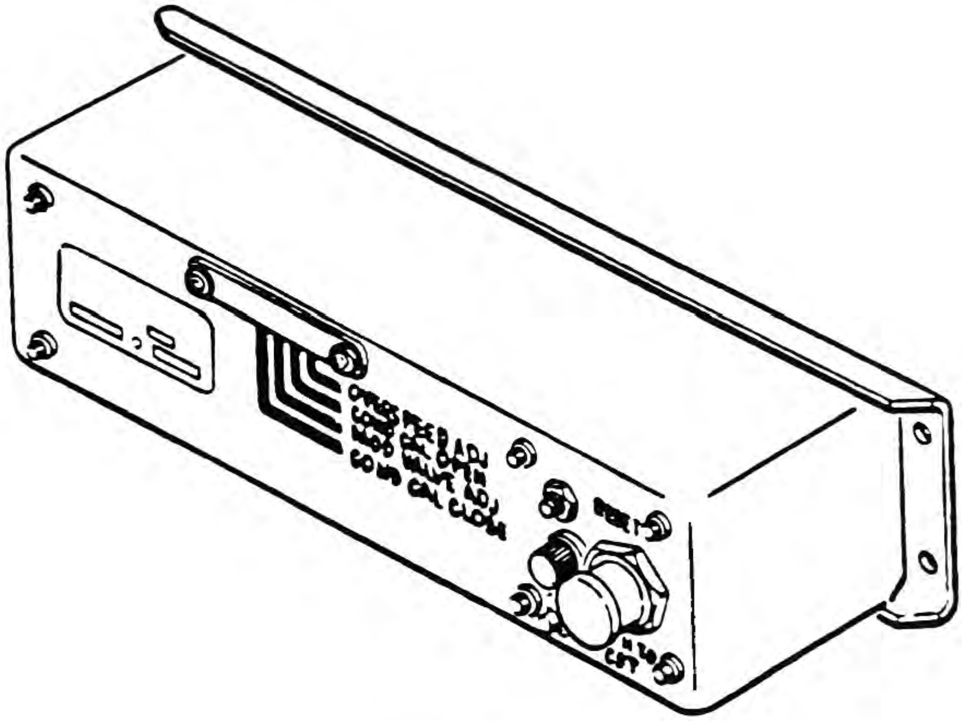
The refrigerant condenser thermistor is located in the condenser liquid header (Figure 21-51) and is equipped with an electrical connector. A change in refrigerant liquid temperature in the header changes the resistance of the thermistor. The thermistor circuit, in conjunction with the refrigeration system controller, positions the condenser exhaust flaps, which control the amount of cooling air flowing through the condenser.

(20) Refrigerant Evaporator Thermistor

The refrigerant evaporator thermistor is located in the air outlet header of the evaporator and senses the temperature of air leaving the evaporator. The thermistor resistance varies in response to a change in evaporator outlet air temperature. The controller, sensing the change in resistance, regulates the compressor speed (through the modulating valve) in order to maintain the evaporator air outlet temperature at approximately 50°F (10°C).

(21) Refrigerant Pressure Cutoff Switch

A refrigerant pressure cutoff switch connected to the compressor discharge line is located on the forward bulkhead of the air-conditioning accessory compartment. The switch shuts down the refrigeration system if compressor discharge pressure exceeds 295 (-0, +20) psig. The switch resets when the high-side pressure decreases 15 to 40 psi.



REFRIGERANT SYSTEM CONTROLLER

FTX80368

Figure 21-54

(22) Engine Throttle Refrigeration Control Switch

The engine throttle refrigeration control switches are located in the pilot control pedestal and form part of the refrigeration system control circuit. When the two throttles on one side are advance 3 inches or more from the idle stop, the switch contacts open to place the refrigeration system in flight mode of operation after an interval of approximately 1-1/4 minutes.

(23) Refrigerant Compressor Differential Pressure Switch

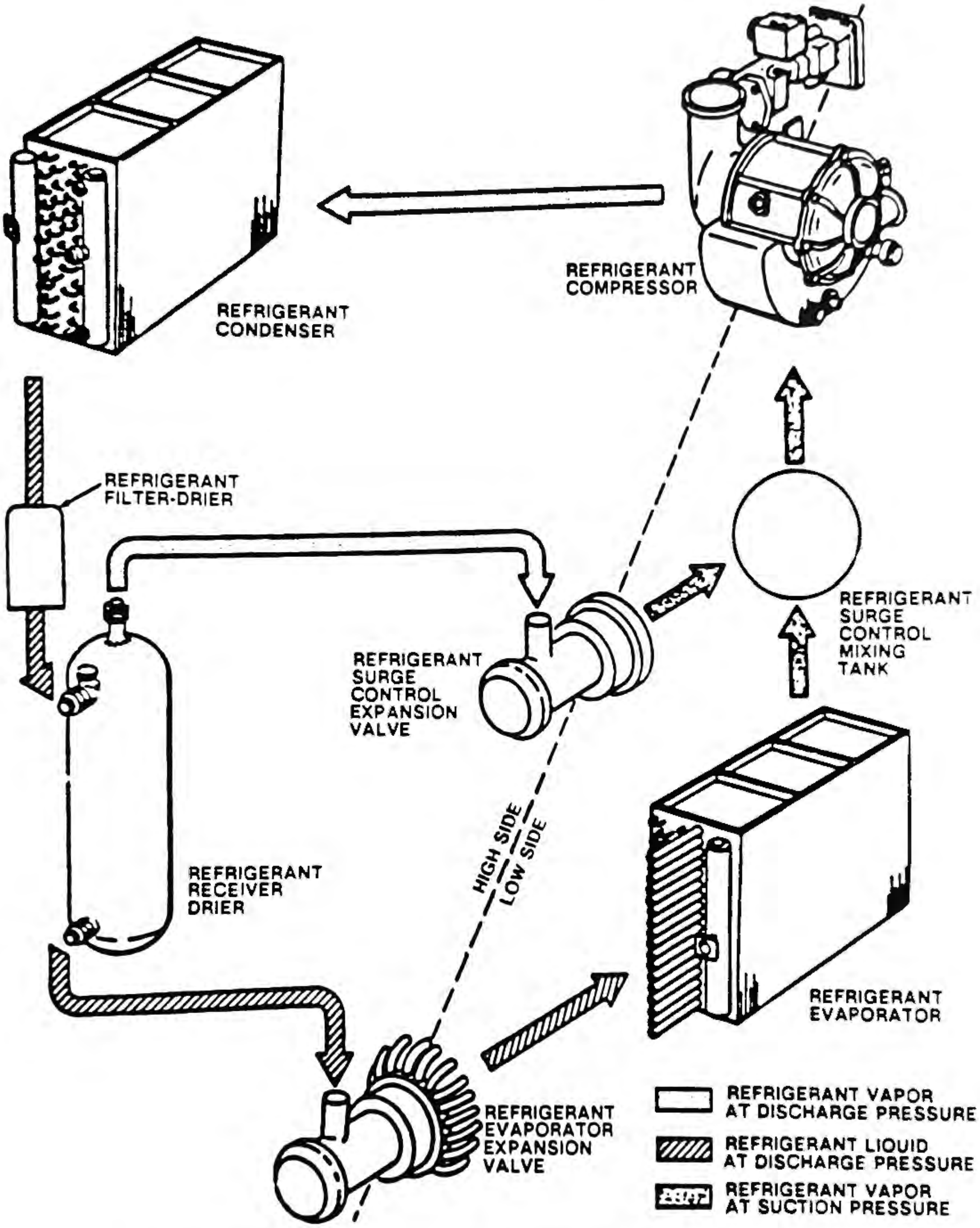
The refrigerant compressor differential pressure switches sense pressure between the refrigerant compressor turbine exhaust duct and the refrigerant compressor pneumatic supply duct downstream of the turbine shutoff valve. If the turbine shutoff valve does not completely close, pneumatic air supply is available to the compressor turbine and the compressor continues to operate. The differential pressure switch contacts remain closed to maintain 115 vac to the compressor oil pump to ensure lubrication to the compressor bearings. The switch contacts close at approximately 1.25 psi while pressure is increasing and open at approximately 0.25 psi when pressure is decreasing.

(24) Evaporator Air Inlet Temperature Switch

An evaporator air inlet temperature switch is located in the evaporator inlet header of each refrigeration system. The switch prevents operation of the refrigeration system when the evaporator air inlet temperature decreases below 44°F (6.7°C). The switch is closed when evaporator inlet air temperature is above 54°F (12.2°C).

(25) Refrigeration Cycle Operation

(a) The basic components of the refrigeration cycle (Figure 21-55) are the refrigerant compressor, refrigerant condenser, refrigerant receiver, refrigerant filter-drier, refrigerant evaporator expansion valve, refrigerant evaporator, surge control tank, and refrigerant surge control expansion valve. The system contains refrigerant 12 and completely sealed and pressurized. Refrigerant 12 has a boiling point at standard atmospheric pressure of -21.6°F (-30.7°C).


REFRIGERANT CONDENSER
REFRIGERANT COMPRESSOR
REFRIGERANT FILTER-DRIER
REFRIGERANT SURGE CONTROL EXPANSION VALVE
REFRIGERANT SURGE CONTROL MIXING TANK
REFRIGERANT RECEIVER DRIER
HIGH SIDE
LOW SIDE
REFRIGERANT EVAPORATOR
REFRIGERANT EVAPORATOR EXPANSION VALVE
REFRIGERANT VAPOR AT DISCHARGE PRESSURE
REFRIGERANT LIQUID AT DISCHARGE PRESSURE
REFRIGERANT VAPOR AT SUCTION PRESSURE

REFRIGERATION CYCLE FUNCTIONAL DIAGRAM

FTX80369

Figure 21-55

sure increases to reduce the overall pressure ratio and damp out or limit compressor surge. The above condition normally occurs during periods of low-evaporator load and/or high-condensing temperatures.

(e) The cool, low-pressure refrigerant gas entering the refrigerant compressor is compressed into hot, high-pressure gas and is discharged to the refrigerant condenser. The high-pressure gas is condensed into high-pressure liquid by the cooling action of ambient air being drawn across the condenser coils. In flight, ram air is used for condenser cooling, and the pneumatically driven condenser fan provides condenser cooling on the ground. Liquid refrigerant from the condenser is discharged into the receiver-drier which contains a strainer equipped with desiccant. Flow of refrigerant 12 around the refrigeration system is continuous

C. Refrigeration Electrical Control Operation

(1) The refrigeration system functions in two modes of operation, the flight mode and ground mode. The freon flight position relay is deenergized in the flight mode and energized in the ground mode. The relay is deenergized (flight mode) on the ground, however, when the engine throttles are advanced approximately 35 degrees (3 inches) from the idle stop. The freon band control relay functions to stop and start the refrigeration cycle by a switch from the systems engineer control panel, if demanded by the air-conditioning mixing valve and if conditions of all components are within operating limits. The following paragraphs describe in detail, from contact to contact, the theory of operation of the refrigeration system, beginning at the airplane energized electrical buses.

(2) When the airplane is on the ground, the freon flight control relay is energized from the 28-vdc freon control circuit breaker, through closed contacts D1 and D2 of the air-conditioning system ground relay and the closed-engine throttle switches. The engine throttle switch contacts are closed when the engine throttles are set less than 70 percent of maximum thrust. Throttles for engines 1 and 2 control the left refrigeration system. With the manual switch in off position, the freon band control relay deenergized, and the circuit breakers closed to make 115 vac and 28 vdc available to the system, the following conditions exist:

B. Component Description

(1) Refrigerant Saturation and Superheat Temperature Indicator

(a) The refrigerant saturation and superheat temperature indicator is a dual ratiometer-type instrument and is calibrated in degrees. The instrument case is 3 inches in diameter and 3 1/2 inches long, with an electrical connector mounted on the back. The left side of the indicator is calibrated to read saturation temperature within the range of -10° to +34°C. The right side of the indicator is calibrated to read superheat temperature within the range of 0° to 30°C.

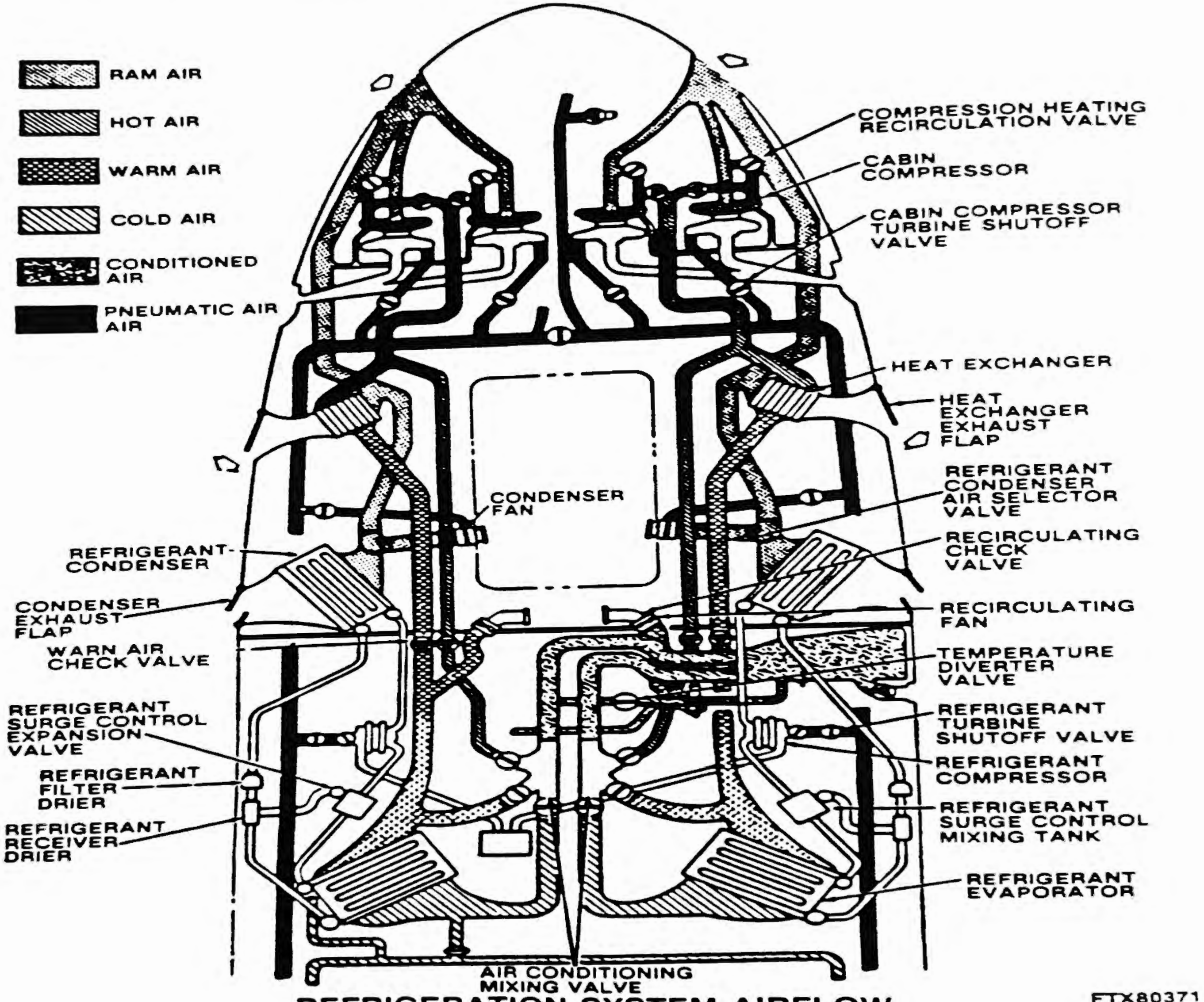
(b) The saturation scale has a green operating band between 4.4° and 15.6°C, but the normal operating range is approximately -6.7° to +15.6°C. The superheat scale has a green operating band between 0° and 11.2°C and a pink band at 20°C. A loss of system electrical power cases both indicator pointers to go to the lower end of the scale.

(2) Refrigerant Evaporator Saturation Temperature Bulb

The refrigerant evaporator saturation temperature bulb is a bayonet-type-resistance probe used to sense the temperature of the refrigerant in the evaporator coils. The bayonet is approximately 3 inches long and is installed in the upper well, which is bonded to a return bend of the evaporator (Figure 21-57). Resistance of the bulb at 32°F (0°C) is 90.38 ohms.

(3) Refrigerant Evaporator Superheat Temperature Bulb

The refrigerant evaporator superheat temperature bulb is similar to the saturation temperature bulb. The superheat temperature bulb senses the temperature of the refrigerant in the evaporator coil, for comparison (in the indicator) with the temperature of the vapor leaving the evaporator. The bulb is mounted in the lower well, which is bonded to a return bend of the evaporator (Figure 21-57). Resistance of the bulb at 32°F is 90.38 ohms.


RAM AIR
HOT AIR
WARM AIR
COLD AIR
CONDITIONED AIR
PNEUMATIC AIR AIR
COMPRESSION HEATING RECIRCULATION VALVE
CABIN COMPRESSOR
CABIN COMPRESSOR TURBINE SHUTOFF VALVE
HEAT EXCHANGER
HEAT EXCHANGER EXHAUST FLAP
REFRIGERANT CONDENSER AIR SELECTOR VALVE
RECIRCULATING CHECK VALVE
RECIRCULATING FAN
TEMPERATURE DIVERTER VALVE
REFRIGERANT TURBINE SHUTOFF VALVE
REFRIGERANT COMPRESSOR
REFRIGERANT SURGE CONTROL MIXING TANK
REFRIGERANT EVAPORATOR
CONDENSER FAN
REFRIGERANT-CONDENSER
CONDENSER EXHAUST FLAP
WARN AIR CHECK VALVE
REFRIGERANT SURGE CONTROL EXPANSION VALVE
REFRIGERANT FILTER DRIER
REFRIGERANT RECEIVER DRIER
AIR CONDITIONING MIXING VALVE
FTX80371

REFRIGERATION SYSTEM AIRFLOW

Figure 21-56

(a) Freon flight position relay contacts A1 and A2 are closed to drive the refrigerant condenser air selector valve to the fan position (flap covering the ram air port).

(b) The refrigerant condenser exhaust flap actuator is energized to the trail position through band control relay closed contacts C2 and C3.

(3) The freon band control relay coil is energized through the flight position relay closed contacts C1 and C2 (ground mode) and the 115 VAC freon control circuit breaker, when the freon compressor switch located on the flight systems engineer control panel is placed in the normal position and when the following conditions are met:

(a) Refrigerant pressure as sensed by the condenser pressure switch is below 255 psig and switch contacts are closed.

(b) The air-conditioning mixing valve is demanding cold air from the refrigeration system (mixing valve camshaft is between 0 and 58.5 degrees of shaft rotation, and the switch contacts are closed).

(c) The ram air duct is covered by the refrigerant condenser air selector valve flapper, therefore the dual contact limit switch is closed.

(d) The condenser fan overspeed switch is not tripped.

(4) With the flight position relay and the band control relay energized the following operations take place:

(a) Band control relay contacts D1 and D2 energize the refrigerant compressor oil pump relay from the 28-vdc refrigerant compressor oil pump circuit breaker relay contact close to energize the compressor oil pump through the 115-vac oil pump circuit breaker.

(b) When oil pressure reaches approximately 45 psig, the refrigerant compressor oil pressure switch contacts close and 115 vac from the freon power circuit breaker is made available to the voltage regulator in the refrigeration system controller, through the band control relay closed contacts C1 and C2, the flight position relay closed contacts D1 and D2, the refrigerant condenser exhaust flap actuator limit switch closed contacts, and the freon turbine regulating position valve closed contacts A1 and A2.

(c) Power is applied to the open condenser flap magnetic amplifier, close condenser flap magnetic amplifier, over and underspeed magnetic amplifier, and the modulating valve magnetic amplifier. When power is first applied, the over and underspeed magnetic amplifier becomes saturated which causes the associated relay to be energized. The relay contacts close, making 28 vdc available from the freon control circuit breaker to the refrigerant turbine shutoff valve solenoid. Simultaneously, 28 vdc is routed through the refrigerant air selector valve (ram duct closed) limit switch to start the condenser fan and to energize the 55-second refrigerant compressor pump oil pressure delay relay. Contacts of the relay are energized immediately and remain closed for 55 seconds after the refrigerant turbine shutoff valve is deenergized. This delay ensures compressor oil pump operation and adequate lubrication until the compressor stops rotation. Further protection against lack of oil pressure to the refrigerant compressor bearings is provided by the refrigerant compressor differential pressure switch. If the pneumatic air supply continues to leak to the refrigerant compressor turbine after the turbine shutoff valve is closed, the differential pressure switch contacts remain closed to complete a parallel 115-VAC circuit to maintain compressor oil pump operation.

(d) The compressor operating indicator light (blue) on the systems engineer control panel is connected in parallel with the refrigerant turbine shutoff valve and comes on when the valve is energized.

(5) When the engine throttles are advanced beyond 70 percent of maximum thrust, or when the airplane leaves the ground, the refrigeration system switches to flight mode and the freon flight position relay is deenergized, allowing the following operations to take place:

(a) Contacts A2 and A3 of the flight position relay close, and the refrigerant condenser air selector valve actuator moves the flap from the ram air port to the condenser fan inlet port. As the flap moves away from the ram air port, the condenser fan limit switch deenergizes the band control relay coil and the condenser fan shutoff valve. This opens contacts C1 and C2 and deenergizes the tor. Superheat is impossible as long as any liquid refrigerant remains to be vaporized. The circuit is energized by 28-VDC from the freon saturation and superheat temperature circuit breaker.

(2) The refrigerant compressor oil overheat switch, installed in the refrigerant compressor, closes when the oil temperature reaches 280 (±10)°F (137.8 (±5.5)°C. Closing the switch completes a 28-VDC circuit from the freon compressor overheat warning circuit breaker (Figure 21-58) through the compressor overheat indicator and the indicating light dimming system.

(3) The pneumatic manifold refrigerant pressure switch sense the pressure in the low-pressure pneumatic ducts of each system and are connected to the indicating circuit to illuminate the freon compressor overheat light when the pressure drops below 12 psig.

refrigeration system controller. Losing power to the controller causes the over and underspeed magnetic amplifier to desaturate. The over and underspeed relay opens to deenergize the turbine shutoff valve and the 55-second compressor pump oil pressure delay relay. The circuit to the fan shutoff valve is also opened when the condenser air selector valve flap moves away from the ram port position. About 10 seconds is required for the refrigerant condenser air selector valve flap to move from one position to another.

(b) The condenser exhaust flap actuator is energized as contacts C2 and C3 of the deenergized band control relay close, driving the flap toward the trail position. The exhaust flap takes approximately 25 seconds to travel from full open position to full trail position.

(c) When the refrigerant condenser air selector valve flap closed the condenser fan inlet port, the ram air flap limit switch is closed and the circuit to the band control relay coil is energized Power is applied to the voltage regulator in the controller, and the sequence of events previously described takes place, except that the refrigerant condenser fan does not start since the limit switch contacts are open. The refrigerant condenser exhaust flap actuator is now controlled by the condenser flap magnetic amplifiers in the controller (contacts B1 and B2 of the band control relay are closed grounding the relays).

(6) The refrigerant compressor speed is controlled by the refrigerant turbine speed modulating valve, the modulating valve magnetic amplifier in the refrigeration system controller, and the refrigerant evaporator thermistor. The temperature of the air leaving the evaporator affects the resistance of the evaporator thermistor, decreasing the resistance for rising air temperature, and increasing the resistance for falling air temperature. This changing resistance effects the DC voltage output of the refrigeration system controller to the turbine modulating valve. Increasing the voltage to the modulating valve causes the valve to open further, thus speeding up the compressor to provide more cooling. Conversely, a decrease in voltage slows the compressor to provide less cooling. The controller is calibrated to maintain 50°F (10°C) outlet air temperature at the evaporator. The turbine speed modulating valve requires several minutes to move from the closed position to full open position, but closes much faster when near the

full open position. The valve movement is retarded by a viscous damper connected to the valve butterfly shaft. The slow-opening device prevents the refrigerant compressor from overspeeding during startup or in response to a demand for increased speed from the controller. The quick-closing feature helps prevent the compressor from overspeeding when there is a sudden increase in pressure in the pneumatic air supply duct, or during a restart after an overspeed trip shutdown. The viscous damper actuates a switch that controls a relay connected in series with the controller. After the system is shutdown the valve takes approximately 60 seconds to return from the full open to within 26 degrees of the closed position. Without the delay feature, the compressor could be started after an over-speed trip before the speed modulating valve closes to a safe operating position.

(7) Overspeed protection for the refrigerant compressor is accomplished through the over and underspeed magnetic amplifier and the refrigerant compressor magnetic pickup which is installed in the compressor. During the normal operating range of the refrigerant compressor, the signal to deenergize the magnetic amplifier is blocked. If compressor overspeed occurs, the magnetic amplifier will desaturate and close the refrigerant turbine shutoff valve to stop the compressor. The over and underspeed magnetic amplifier will also desaturate if a speed signal from the magnetic pickup in the compressor is not received by the controller in approximately 3 seconds, or if the speed signal is lost during normal operation. A push-to-test switch is incorporated on the controller to check operation of the overspeed. Pressing the button allows the overspeed circuit to operate at a lower rpm. When the overspeed circuit is activated to stop the compressor, the system remains off until the compressor switch is placed in the off position (to deenergize the band control relay) then on again, or a reset switch located on the controller is pressed.

(8) Overheat protection for the refrigerant compressor is accomplished through the refrigerant compressor discharge overtemperature switch which is installed in the compressor discharge elbow. Should an overheat condition exist, the discharge overtemperature switch normally-closed-contacts open the control circuit to the freon band control relay coil and shuts down the system. When the overheat condition returns to normal, the discharge over-temperature switch contacts close to again energize the freon band control relay coil, and ultimately regain freon system operation.

(9) Overspeed protection for the condenser fan is provided by the condenser fan overspeed switch. The switch is connected in series between the flight position relay contact C1 and the condenser air selector valve ram duct limit switch. When a condenser fan overspeed condition exists, the switch contacts open the control circuit to the freon band control relay coil if the airplane is in ground mode of operation. To return the system to normal after a condenser fan overspeed condition the condenser fan mechanical overspeed trip mechanism must be reset manually.

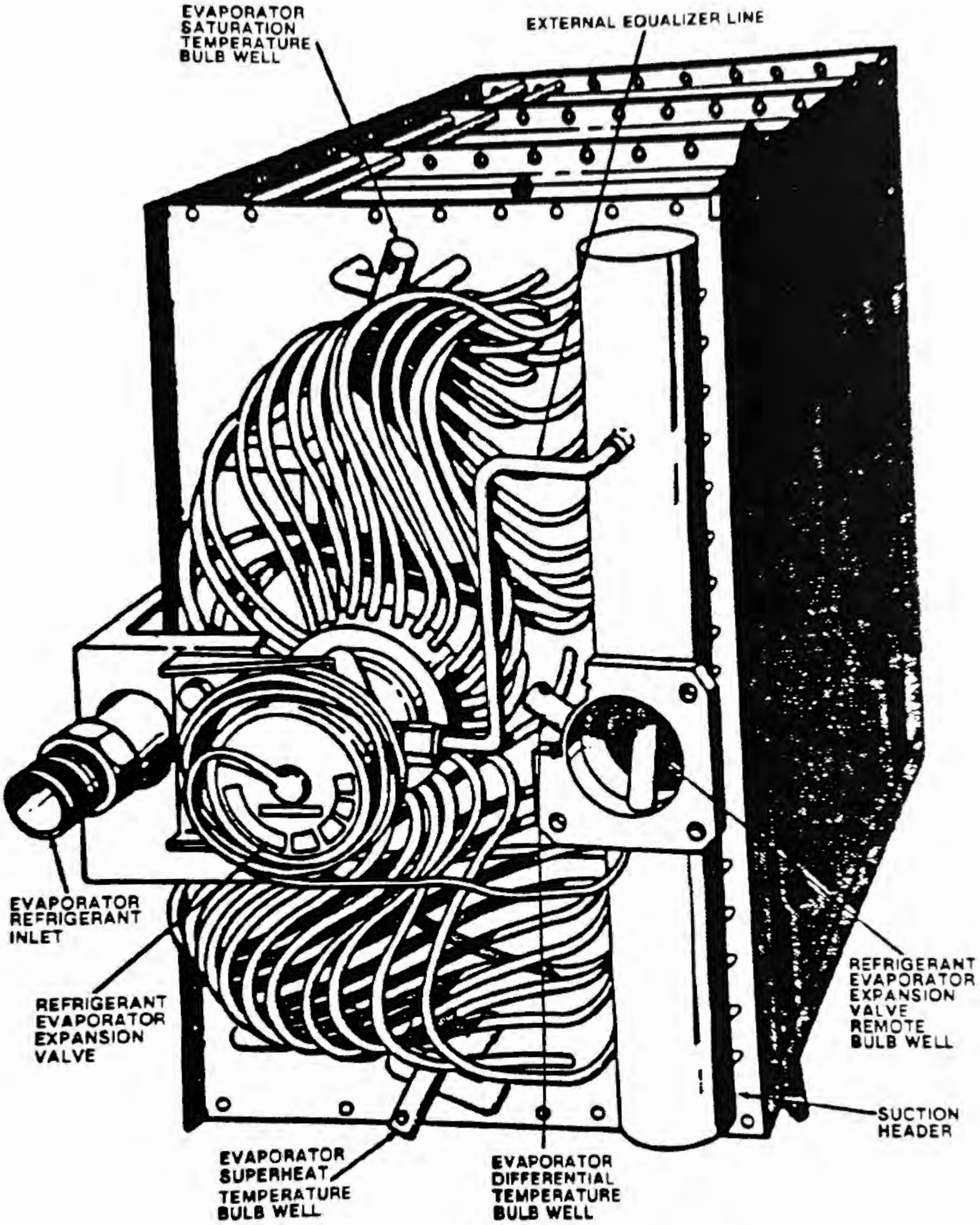
(10) Automatic opening and closing of the refrigerant condenser exhaust flap is controlled by the two magnetic amplifiers in the refrigeration system controller and the refrigerant condenser thermistor installed in the condenser inlet header if the airplane is in flight mode. The magnetic amplifiers compare the output of the refrigerant condenser thermistor, which is sensing the temperature of the refrigerant leaving the condenser. The two magnetic amplifiers are calibrated at a specific turbine rpm and condenser temperature for a null output to the condenser exhaust flap actuator. From this null setting, an increase in temperature at the condenser causes the condenser exhaust flap to open at a steady rate. A timing circuit in the close condenser flap magnetic amplifier pulses the exhaust flap closed. As the error signal increases, the on time of the pulse is increased.

(11) A refrigerant compressor oil pump test switch is installed adjacent to the differential pressure switches on the forward bulkhead of the air-conditioning accessory compartment. The switch completes a 115-vac circuit from the freon compressor oil pump circuit breaker to both refrigerant compressor oil pumps to test operation of the pumps without operating the refrigeration system.

10. Refrigeration Indication - Description and Operation

A. General

Refrigeration indication components provide the operator with visual indication of refrigeration system operation. The system has a dual gage-type refrigerant saturation and superheat temperature indicator that functions with the temperature sensing bulbs installed in the refrigerant evaporator. A compressor overheat amber indicator light comes on when the refrigerant compressor oil overheat switch senses oil overtemperatures in the compressor oil sump.


EVAPORATOR SATURATION TEMPERATURE BULB WELL
EXTERNAL EQUALIZER LINE
EVAPORATOR REFRIGERANT INLET
REFRIGERANT EVAPORATOR EXPANSION VALVE
REFRIGERANT EVAPORATOR EXPANSION VALVE REMOTE BULB WELL
SUCTION HEADER
EVAPORATOR SUPERHEAT TEMPERATURE BULB WELL
EVAPORATOR DIFFERENTIAL TEMPERATURE BULB WELL

REFRIGERANT EVAPORATOR INDICATING TEMPERATURE BULB LOCATIONS

FTX80372

Figure 21-57

(4) Refrigerant Evaporator Differential Temperature Bulb

The refrigerant evaporator differential temperature bulb is identical to the saturation temperature bulb, and is installed in a well that is brazed to the suction header of the vaporator (Figure 21-57). Resistance of the bulb at 32°F (0°C) is 90.35 ohms.

(5) Refrigerant Compressor Oil Overheat Switch

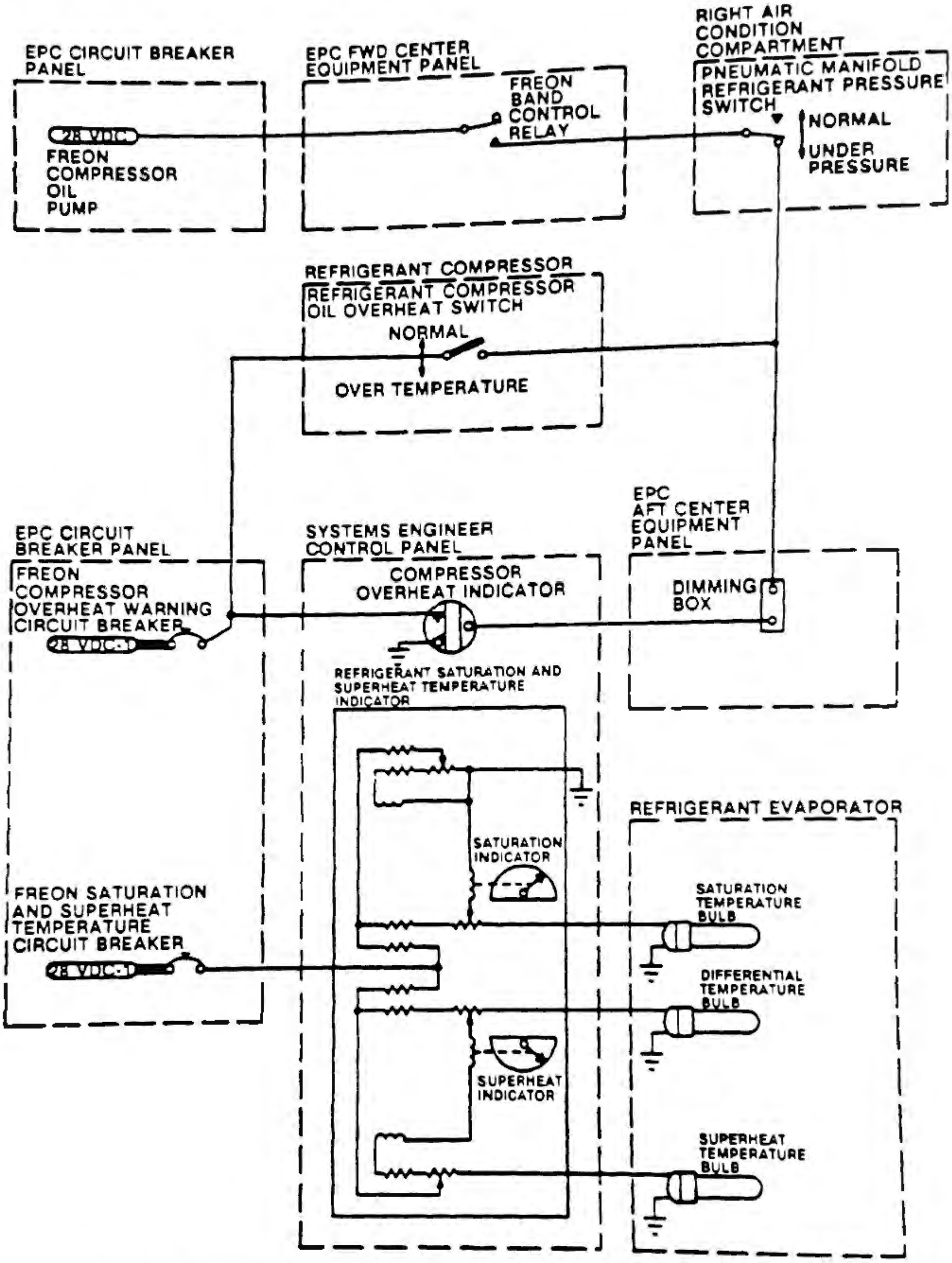
The refrigerant compressor oil overheat switch is a thermally actuated switch used for sensing compressor oil overtemperatures. An electrical receptacle is incorporated in the end of the switch, which is installed at the bottom of the oil sump in each compressor. The switch contacts close when the oil temperature reaches 280 (± 10)°F (137.8 (± 5.5)°C.

(6) Pneumatic Manifold Refrigerant Pressure Switch

The pneumatic manifold pressure switch is a pneumatically actuated switch used for sensing pneumatic manifold underpressures. An electrical receptacle and sense line are incorporated on the switch, which is installed on the aft bulkhead of the cabin compressor compartment. The switch contacts close when the pressure in the pneumatic manifold drops below 12 psig.

C. Operation

(1) Saturation temperature is the boiling temperature of liquid refrigerant 12 at any given pressure. Saturation temperature remains constant as long as any liquid refrigerant is present and the pressure remains constant. Saturation temperature is measured by the saturation temperature bulb, which is electrically connected to the saturation side of the saturation and superheat temperature indicator (Figure 21-58). Superheat temperature is the temperature differential between saturation temperature and actual vapor temperature. The superheat temperature is the difference between the temperature sensed in the evaporator suction header by the differential temperature bulb and the saturation temperature as sensed by the superheat temperature bulb installed in the evaporator coils. Both bulbs are electrically connected to the superheat side of the indicator. Any degree of superheat indicated on the superheat indicator is evidence that all the refrigerant has been vaporized before leaving the evapora-


EPC CIRCUIT BREAKER PANEL
28 VDC
FREON COMPRESSOR OIL PUMP
EPC FWD CENTER EQUIPMENT PANEL
FREON BAND CONTROL RELAY
RIGHT AIR CONDITION COMPARTMENT
PNEUMATIC MANIFOLD REFRIGERANT PRESSURE SWITCH
NORMAL
UNDER PRESSURE
REFRIGERANT COMPRESSOR
REFRIGERANT COMPRESSOR OIL OVERHEAT SWITCH
NORMAL
OVER TEMPERATURE
EPC CIRCUIT BREAKER PANEL
FREON COMPRESSOR OVERHEAT WARNING CIRCUIT BREAKER
28 VDC-1
SYSTEMS ENGINEER CONTROL PANEL
COMPRESSOR OVERHEAT INDICATOR
EPC AFT CENTER EQUIPMENT PANEL
DIMMING BOX
REFRIGERANT SATURATION AND SUPERHEAT TEMPERATURE INDICATOR
SATURATION INDICATOR
REFRIGERANT EVAPORATOR
SATURATION TEMPERATURE BULB
FREON SATURATION AND SUPERHEAT TEMPERATURE CIRCUIT BREAKER
28 VDC-1
DIFFERENTIAL TEMPERATURE BULB
SUPERHEAT INDICATOR
SUPERHEAT TEMPERATURE BULB

REFRIGERATION INDICATION ELECTRICAL SCHEMATIC

FTX80373

Figure 21-58

11. Radio Rack Cooling - Description and Operation

A. General (Figures 21-59 & 21-60)

(1) The radio rack cooling system controls and directs the flow of flight compartment exhaust air, to ventilate and cool the electrical and electronic components installed in the radio rack and other installations in the flight compartment. The system also functions to evacuate smoke and fumes from the flight compartment and to heat the forward lower cargo compartments. Installations are so arranged that flow of exhaust air from the flight compartment is through the consoles, the control pedestal, and equipment panels to the radio rack. After leaving the radio rack, airflow is either directed overboard through the venturi, or to ducts connected to the forward cargo compartment underfloor area.

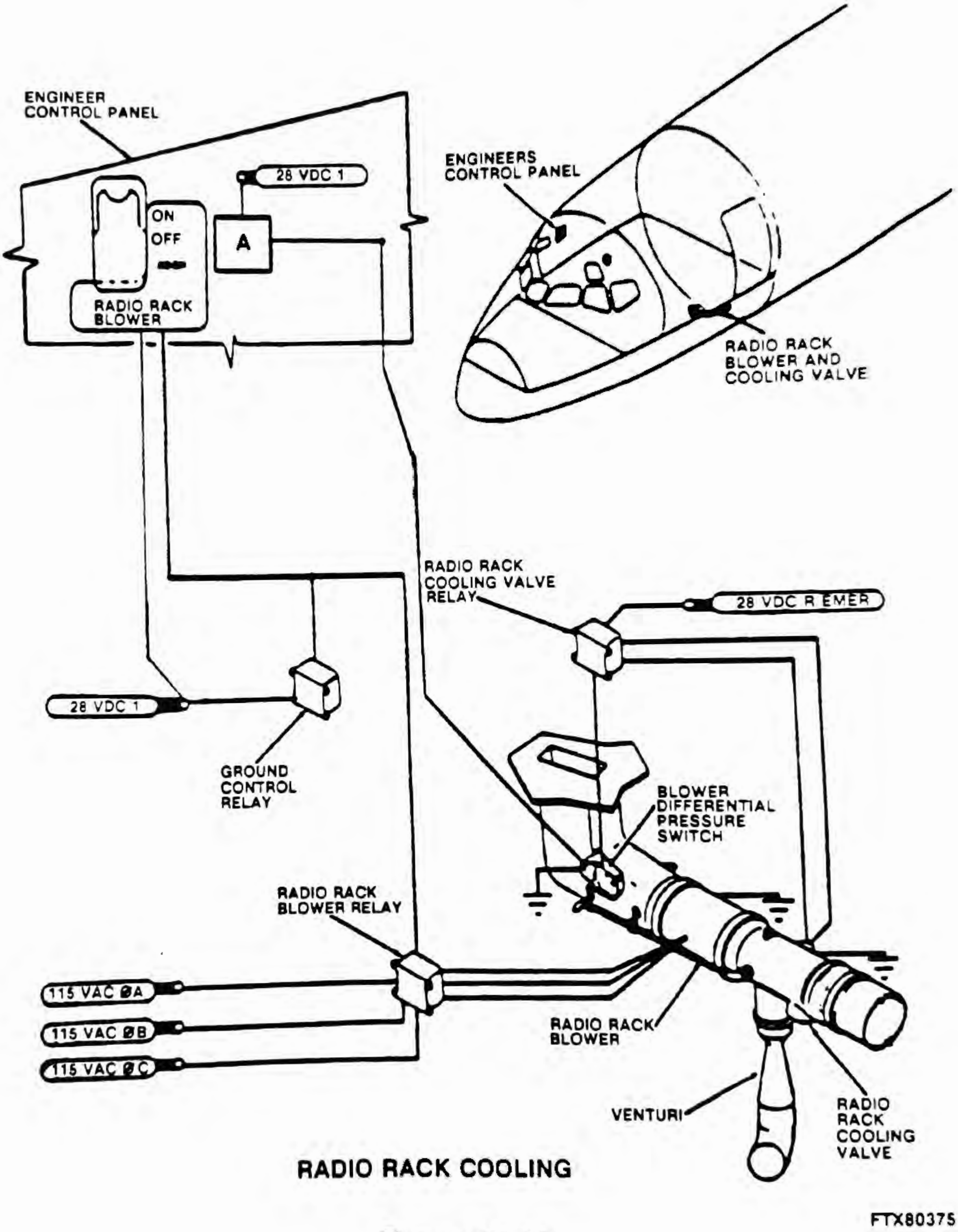
(2) When the airplane is pressurized, cabin-to-atmosphere differential pressure creates the airflow from the flight compartment, through the radio rack, to the radio rack venturi. When the airplane is unpressurized, airflow across the installed equipment is provided by the radio rack blower.

B. Component Description (Figure 21-61)

(1) Radio Rack Blower

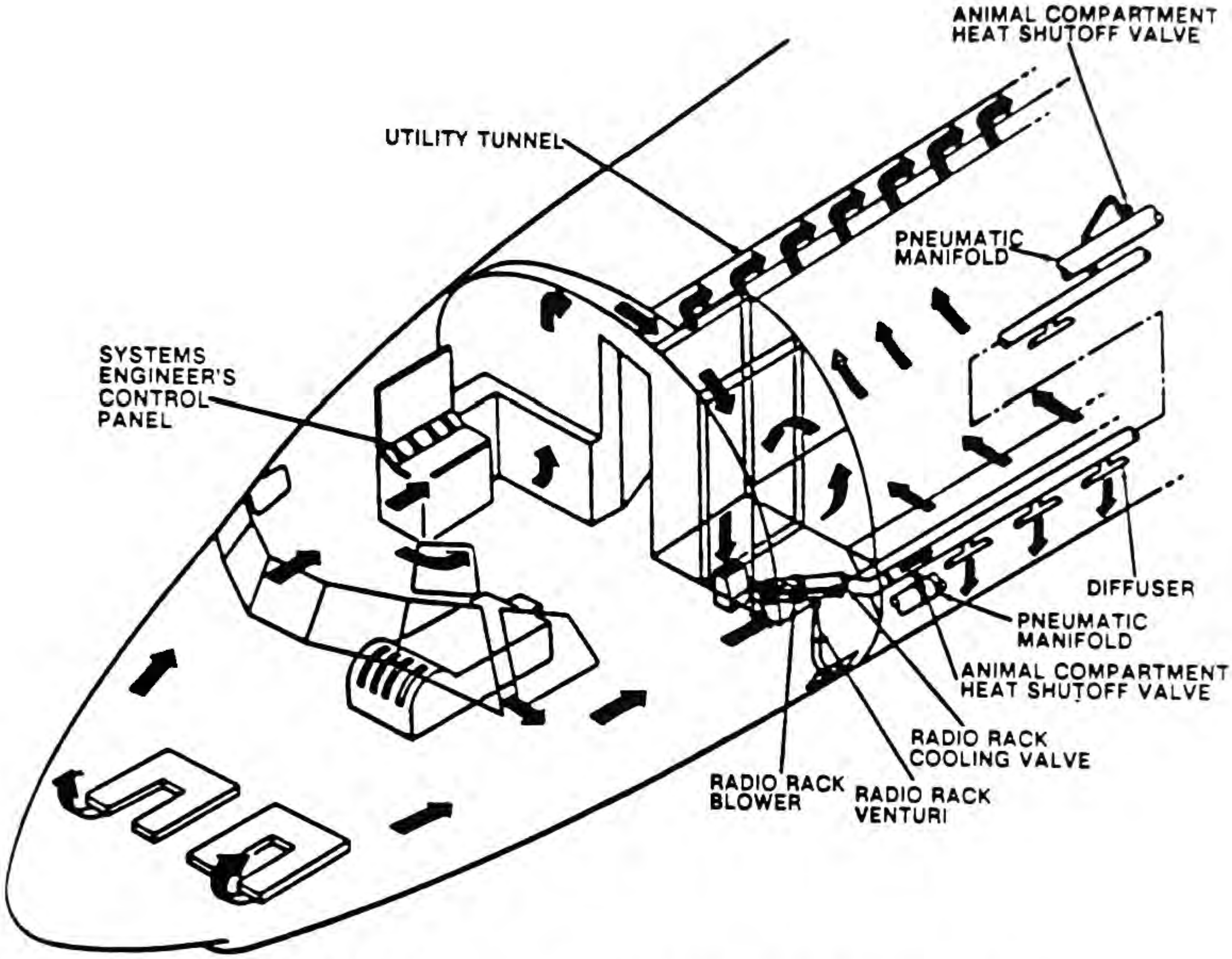
(a) The radio rack blower is installed in a section of ducting between the radio rack floor outlet and the radio rack cooling valve. The blower switch (guarded in normal position) is located on the upper section of the systems engineer control panel. The blower is also used to flow radio rack cooling exhaust air beneath the forward cargo compartment floor, to heat that compartment.

(b) The radio rack blower is a single-stage, axial flow, electrically driven fan, powered by a 3-phase, 200-vac motor. The motor is totally enclosed and explosion proof, and incorporates an internal thermal protection switch which shuts off the motor when temperatures reach approximately 300°F (148.9°C). The switch automatically resets and allows the motor to start when the motor has cooled to a safe operating temperature of approximately 200°F (93.3°C). Under normal conditions, the thermal switch resets in approximately 10 minutes.



RADIO RACK COOLING

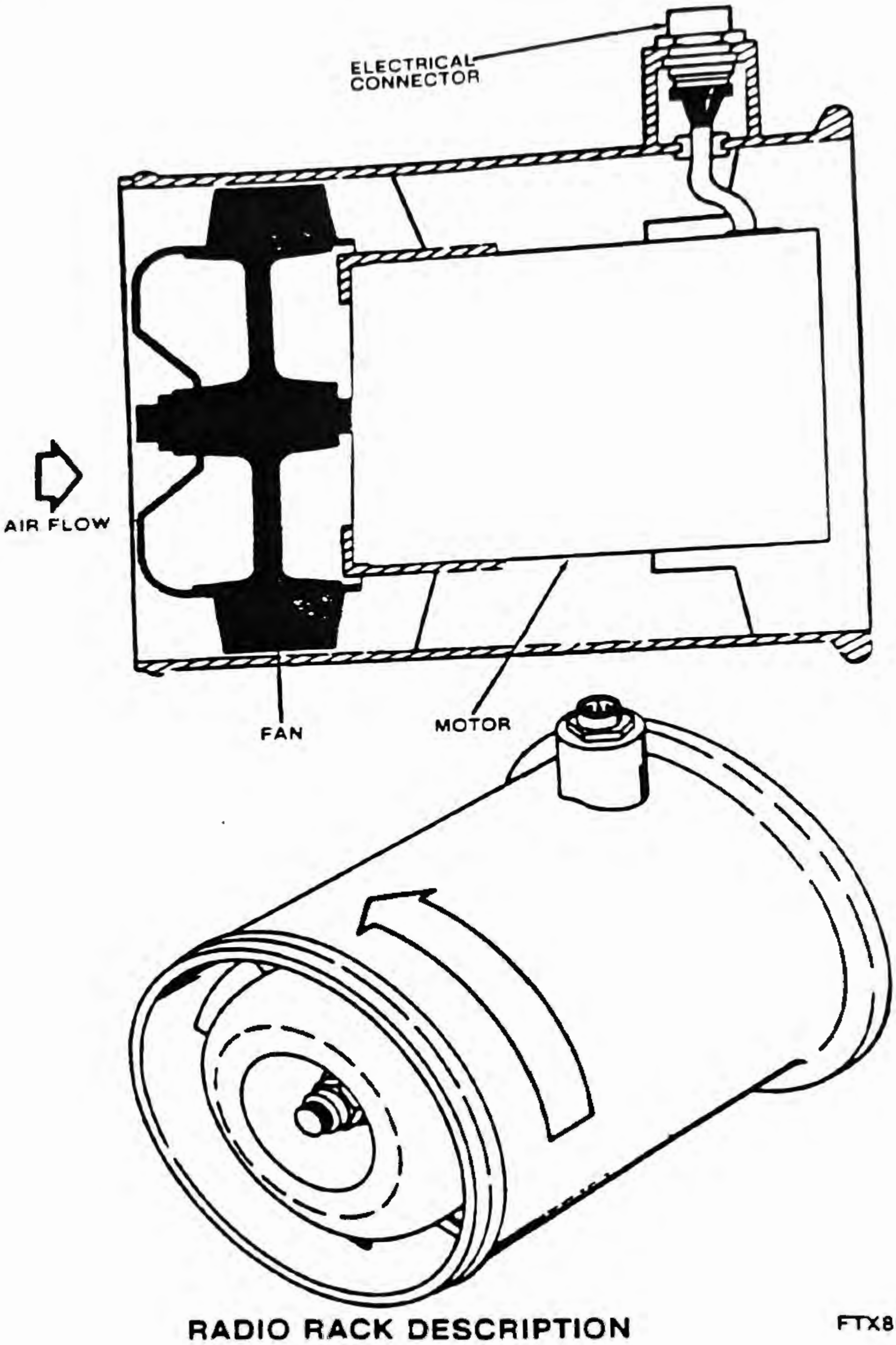
Figure 21-59



RADIO RACK COOLING MECHANICAL SCHEMATIC

FTX80378

Figure 21-60



RADIO RACK DESCRIPTION

FTX80376

Figure 21-61

(2) Radio Rack Cooling Valve (Figure 21-62)

(a) The radio rack cooling valve is located downstream of the radio rack blower and directs airflow from the radio rack to either the forward cargo compartment heating ducts, or the venturi and overboard exhaust. The valve is driven closed when the radio rack blower is operating, and opens when the blower stops.

(b) The radio rack cooling valve is a 2-position, electrically actuated valve consisting of one inlet port, two exhaust ports, and two butterfly valves. One of the exhaust ports connects to a duct leading to the double floor area of the forward cargo compartment. The other connects to the flow limiting venturi leading overboard. One butterfly valve is located in the port leading to the cargo compartment duct. The other butterfly valve is located in the duct leading to the cooling venturi. The butterflies are operated by the actuator mounted on the valve and are mechanically linked so that when one butterfly opens the other closes. The valve is open when the butterfly in the port connected to the cooling venturi is open, and the butterfly in the port to the forward cargo compartment duct is closed.

(3) Fan Differential Pressure Switch

(a) The fan differential pressure switch is located adjacent to the radio rack blower on the left side of the air conditioning accessory compartment. The pressure switch senses pressure differential across the fan and is connected by sense lines to the duct upstream of the blower, and the radio rack cooling valve downstream of the blower.

(b) The pressure switch consists of a switch actuator, a switch, and a pressure plate assembly which is actuated by movement of a diaphragm. When pressure differential across the cooling fan falls below a pressure equal to 2 1/2 inches of water, the switch closes, completing an electrical circuit to the rack overheat warning light located on the systems engineer control panel. The switch opens when the increasing pressure equals 5 inches of water.

(3) Air-Conditioning Heat Exchanger Exhaust flap Actuator

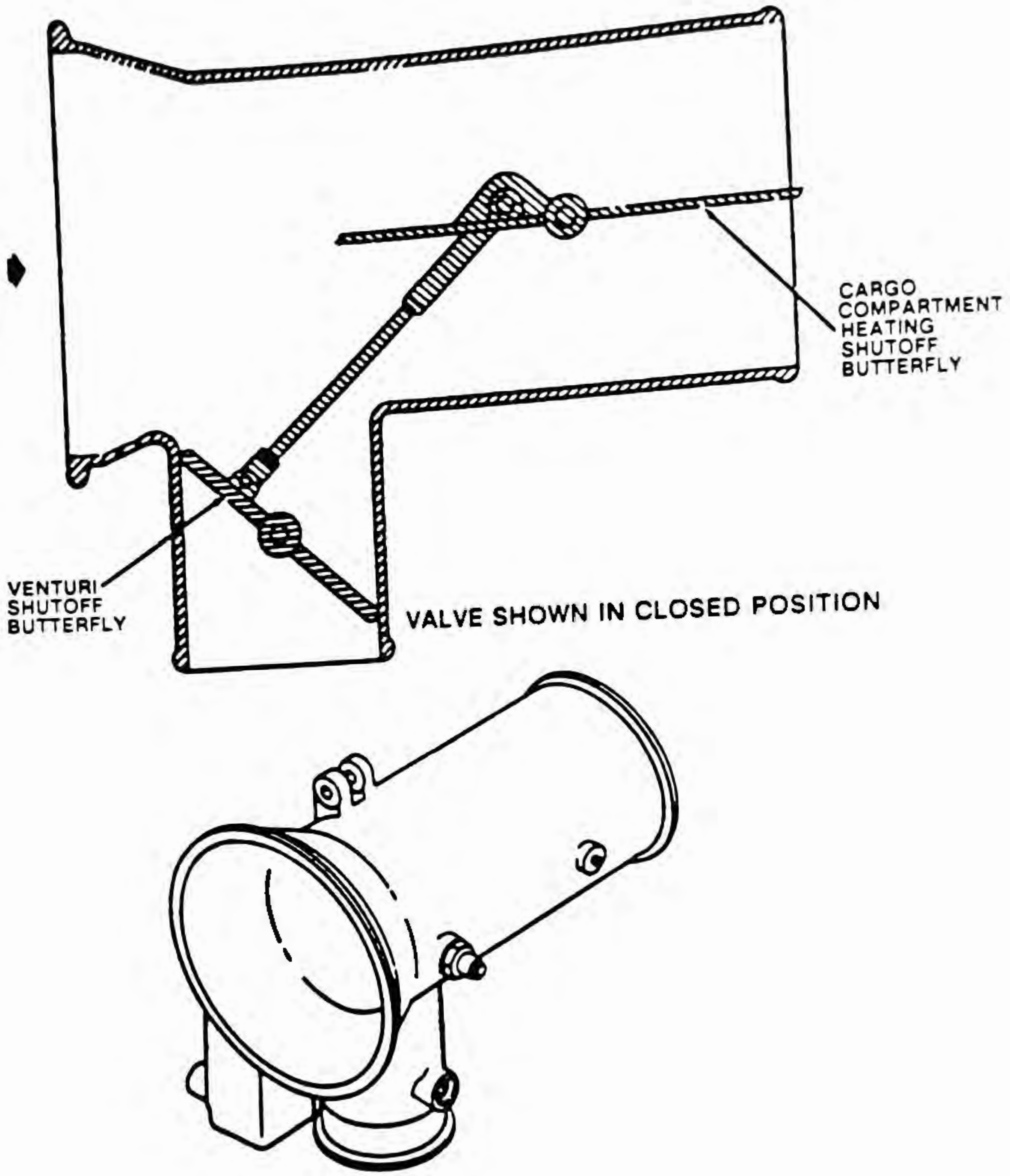
(a) The air-conditioning heat exchanger exhaust flap actuator is controlled by the air-conditioning heat exchanger amplifier that functions in conjunction with the air-conditioning mixing valve. The actuator consists of an electric motor, a gear train, two limit switches, and a potentiometer. The actuator is bracket mounted, with an actuating arm extending into the heat exchanger exhaust duct, and attached to the exhaust flap. The rotary movement of the actuator opens or closes the exhaust flap.

(b) The limit switches establish the operating limits of the arm in either direction. The wiper arm of the potentiometer is moved by the actuator so that the resistance of the potentiometer varies with actuator movement. The potentiometer resistance affects a portion of the controlling bridge circuitry, and, when the resistance of the potentiometer balances the bridge, the actuator stops.

C. System Operation

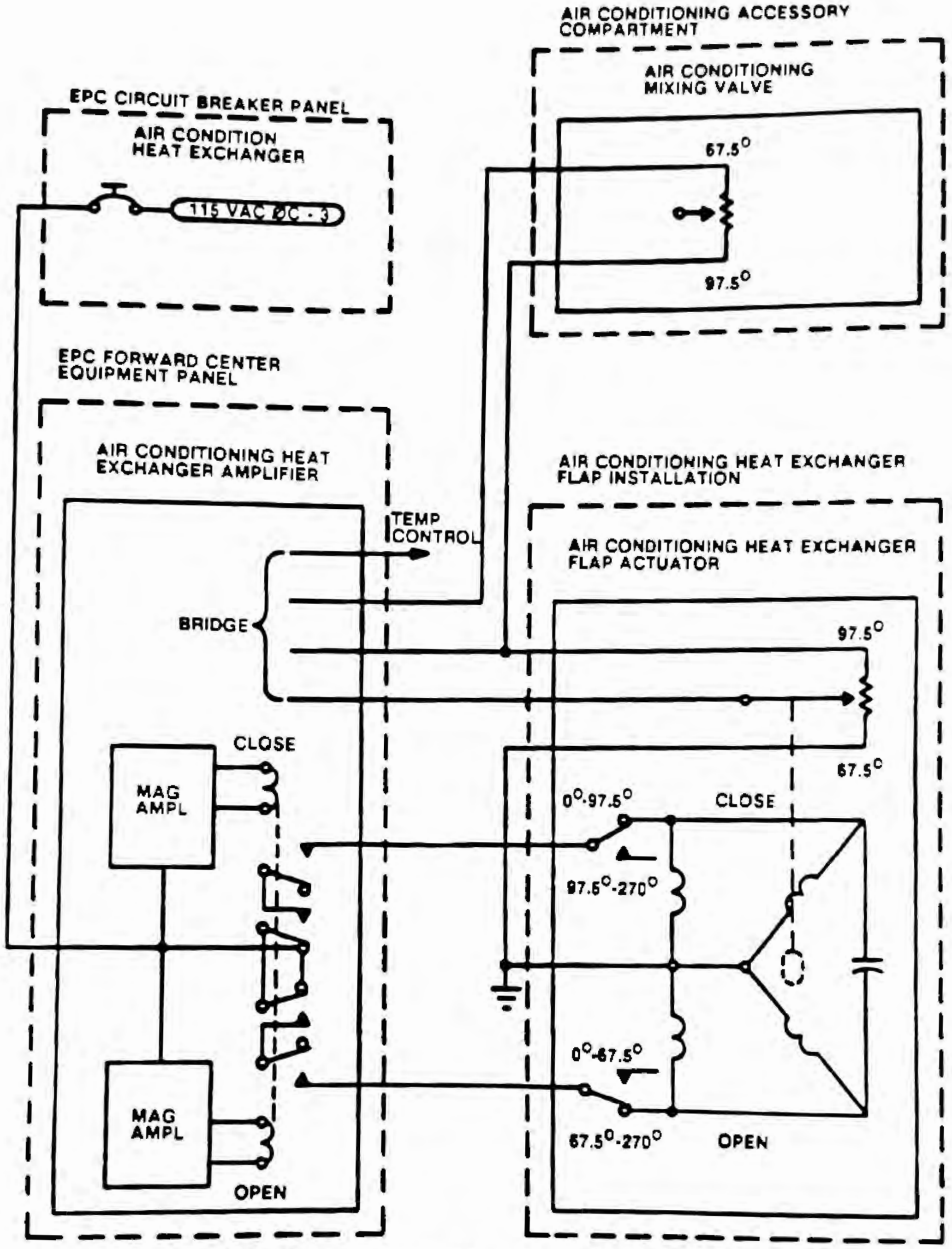
(1) Part of the hot air from the cabin compressors is passed through the heat exchanger, then to the warm air port of the air-conditioning mixing valve and the refrigerant evaporator. Ram air, which is directed through the heat exchangers at 90 degrees to the hot airflow, absorbs heat from the hot air passing through the thin wall metal passages and then exhausts overboard. The amount of cooling performed by the heat exchangers is controlled by the amount of ram air allowed to flow through the heat exchanger. This governs the amount of heat removed from the warm air supply. Ram airflow is regulated by controlling the position of the flap installed in the heat exchanger ducts, and the flap is controlled by the electrically driven actuator.

(2) Since the position of the air-conditioning heat exchanger exhaust flap determines the amount of cooling ram airflow across the heat exchanger, the relative position of the actuator controls the air temperature delivered to the air-conditioning mixing valve. The air-conditioning heat exchanger amplifier controls the direction and degree of rotation of the flap actuator by controlling power to the electric motor (Figure 21-65). When the air-conditioning mixing valve responds to demands of the temperature control system, movement of the valve moves the wiper arm of the potentiometer that forms part of the control bridge circuitry for the heat exchanger exhaust flap


CARGO COMPARTMENT HEATING SHUTOFF BUTTERFLY
VENTURI SHUTOFF BUTTERFLY
VALVE SHOWN IN CLOSED POSITION
FTX80377

RADIO RACK COOLING VALVE

Figure 21-62


AIR CONDITIONING ACCESSORY COMPARTMENT
AIR CONDITIONING MIXING VALVE
67.5°
97.5°
EPC CIRCUIT BREAKER PANEL
AIR CONDITION HEAT EXCHANGER
115 VAC ØC - 3
EPC FORWARD CENTER EQUIPMENT PANEL
AIR CONDITIONING HEAT EXCHANGER AMPLIFIER
TEMP CONTROL
BRIDGE
CLOSE
MAG AMPL
MAG AMPL
OPEN
AIR CONDITIONING HEAT EXCHANGER FLAP INSTALLATION
AIR CONDITIONING HEAT EXCHANGER FLAP ACTUATOR
97.5°
67.5°
0°-97.5°
CLOSE
97.5°-270°
0°-67.5°
67.5°-270°
OPEN

AIR-CONDITIONING HEAT EXCHANGER EXHAUST FLAP CONTROL ELECTRICAL SCHEMATIC

FTX80381

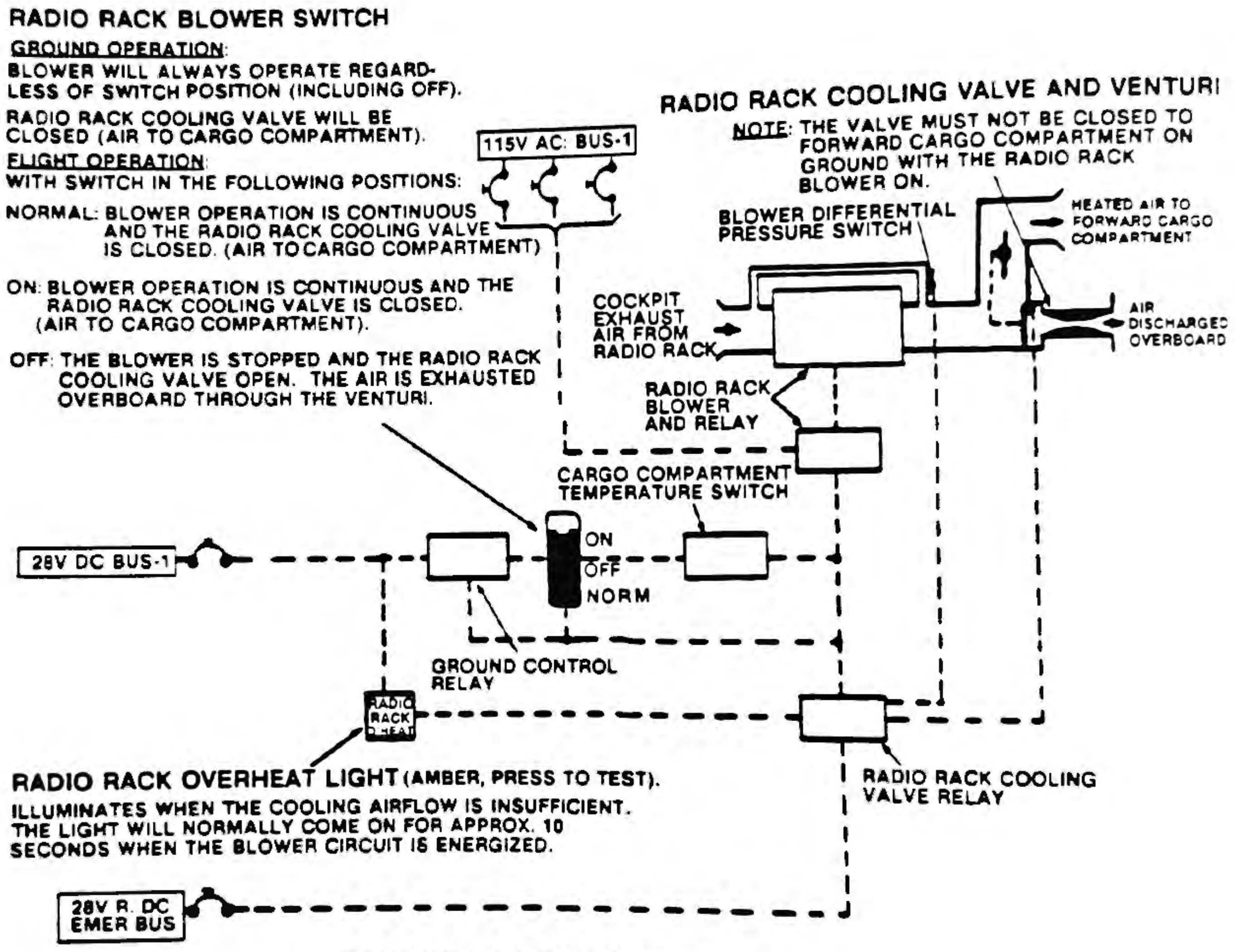
Figure 21-65

C. System Operation

(1) The radio rack cooling fan is controlled by a three position switch on the flight engineer's overhead panel. When the airplane is in flight and the radio rack cooling fan switch is in the normal or on position, the radio rack cooling fan runs continuously. Air is drawn from the cockpit through the consoles, EPC panels, and radio rack and exhausted under the forward cargo compartment floor. When the radio rack cooling fan switch is in the off position the radio rack fan is inoperative and the radio rack cooling valve is positioned to the venturi mode. The size of the shrouds, ducts and venturi is sufficient to ensure cooling airflow for the installed equipment as long as the aircraft is pressurized. During operations in the venturi mode air flows from the radio rack, through the inoperative blower, and is directed overboard through the venturi by the open radio rack cooling valve.

(2) When the airplane is on the ground, and 115-VAC and 28-VDC is available at the electrical buses, radio rack blower power circuits and the radio rack cooling valve close circuits are energized regardless of the blower switch position (Figure 21-63). The radio rack blower relay and radio rack cooling valve relay are energized through contacts of the ground control relay. The radio rack blower relay contacts close to energize the blower motor with-phase, 115-vac power. Closed contacts A2 and A1 of the radio rack cooling valve relay supply 28-vdc from the emergency bus to the close solenoid of the radio rack cooling valve. Close contacts B2 and B1 arm the rack overheat indicator circuits from the radio rack blower warning circuit breaker, through the dimming box and the radio rack blower differential pressure switch. If a pressure of 2 1/2 to 5 inches of water is not sensed downstream of the blower, the radio rack blower differential pressure switch contacts remain closed to light the rack overheat indicator.

(3) The rack overheat indicator is provided to warn the operator when insufficient cooling air is flowing through the electrical and electronic equipment racks. When electrical power is first applied to the airplane electrical buses, the indicating light may come on momentarily until the pressure differential across the radio rack blower increase sufficiently to close the switch contacts. Under normal conditions, the light should go off within 10 seconds after power is applied to the blower circuits.



RADIO RACK BLOWER SWITCH

GROUND OPERATION:
BLOWER WILL ALWAYS OPERATE REGARDLESS OF SWITCH POSITION (INCLUDING OFF).
RADIO RACK COOLING VALVE WILL BE CLOSED (AIR TO CARGO COMPARTMENT).

FLIGHT OPERATION:
WITH SWITCH IN THE FOLLOWING POSITIONS:

NORMAL: BLOWER OPERATION IS CONTINUOUS AND THE RADIO RACK COOLING VALVE IS CLOSED. (AIR TO CARGO COMPARTMENT)

ON: BLOWER OPERATION IS CONTINUOUS AND THE RADIO RACK COOLING VALVE IS CLOSED. (AIR TO CARGO COMPARTMENT).

OFF: THE BLOWER IS STOPPED AND THE RADIO RACK COOLING VALVE OPEN. THE AIR IS EXHAUSTED OVERBOARD THROUGH THE VENTURI.

RADIO RACK COOLING VALVE AND VENTURI

NOTE: THE VALVE MUST NOT BE CLOSED TO FORWARD CARGO COMPARTMENT ON GROUND WITH THE RADIO RACK BLOWER ON.

RADIO RACK OVERHEAT LIGHT (AMBER, PRESS TO TEST).
ILLUMINATES WHEN THE COOLING AIRFLOW IS INSUFFICIENT. THE LIGHT WILL NORMALLY COME ON FOR APPROX. 10 SECONDS WHEN THE BLOWER CIRCUIT IS ENERGIZED.

115V AC: BUS-1
BLOWER DIFFERENTIAL PRESSURE SWITCH
HEATED AIR TO FORWARD CARGO COMPARTMENT
COCKPIT EXHAUST AIR FROM RADIO RACK
AIR DISCHARGED OVERBOARD
RADIO RACK BLOWER AND RELAY
CARGO COMPARTMENT TEMPERATURE SWITCH
28V DC BUS-1
ON
OFF
NORM
GROUND CONTROL RELAY
RADIO RACK
RADIO RACK COOLING VALVE RELAY
28V R. DC EMER BUS

RADIO RACK BLOWER SCHEMATIC

FTX80379

Figure 21-63

(b) The condenser is located on the opposite side of the module from the drive belt. The freon is cooled and converted to a liquid, as air, which is drawn from the nose wheel well by a fan mounted directly to the drive motor shaft, passes over the coils. The air which was used for cooling (condensing) is exhausted overboard through a screened panel located on the right side of the fuselage.

(c) A receiver/dryer and filter assembly is mounted to the compressor/condenser module. The receiver/dryer is used to store liquid refrigerant, and remove moisture and foreign particles as the refrigerant circulates within the system (Figure 21-67). The unit also contains a sight glass for checking freon charge, and a binary pressure switch which senses abnormal pressure ranges. The pressure switch is a dual function switch that will remove power from the compressor drive motor power relay if an over pressure or under pressure condition should occur. The switch is set to operate if the freon pressure should rise above 300 ± 30 psig, and will reset when the pressure drops to 200 ± 20 psig; or when the pressure drops to 30-15 psig, and will reset when pressure rises to 40 psig.

(2) Evaporator Unit

(a) There are two identical evaporator units located in the cockpit, one forward and one aft. The fwd unit is located aft of the captain's briefcase holder, and the aft unit is mounted overhead at the aft end of the cockpit. Each unit contains an evaporator with filter, blower motor and fan, and an expansion valve. The blower motor is a 115 vac motor powered by the supp air conditioning control circuit breaker on the AC radio bus-3 (N56).

(b) In operation, the high-pressure liquid refrigerant is injected into the coil by the expansion valve. The expansion valve sprays refrigerant to the evaporator to facilitate refrigerant evaporation and controls the amount of refrigerant passing through the valve orifice. As the temperature of the refrigerant passing through the coils is much cooler than the cabin air which is blown over the coils, heat from the cabin air is absorbed by the refrigerant, cooling the cabin air. Before the refrigerant has passed completely through the coils, the liquid has evaporated. Water is also removed from the air as condensates and drained overboard.

12. Air-Conditioning Heat Exchanger Exhaust Flap Control - Description and Operation

A. General

The air-conditioning heat exchanger exhaust flap control (Figure 21-64), one for each air-conditioning system, consists of a potentiometer in the air-conditioning mixing valve, an air-conditioning heat exchanger amplifier, and a heat exchanger exhaust flap and actuator. The purpose of the system is to control the position of the heat exchanger exhaust flap during air-conditioning mixing valve port B operation. The exhaust flap actuator contains a potentiometer, which forms a bridge with the potentiometer in the air-conditioning mixing valve. The air-conditioning heat exchanger amplifier positions the exhaust flap actuator in response to the bridge circuit signals.

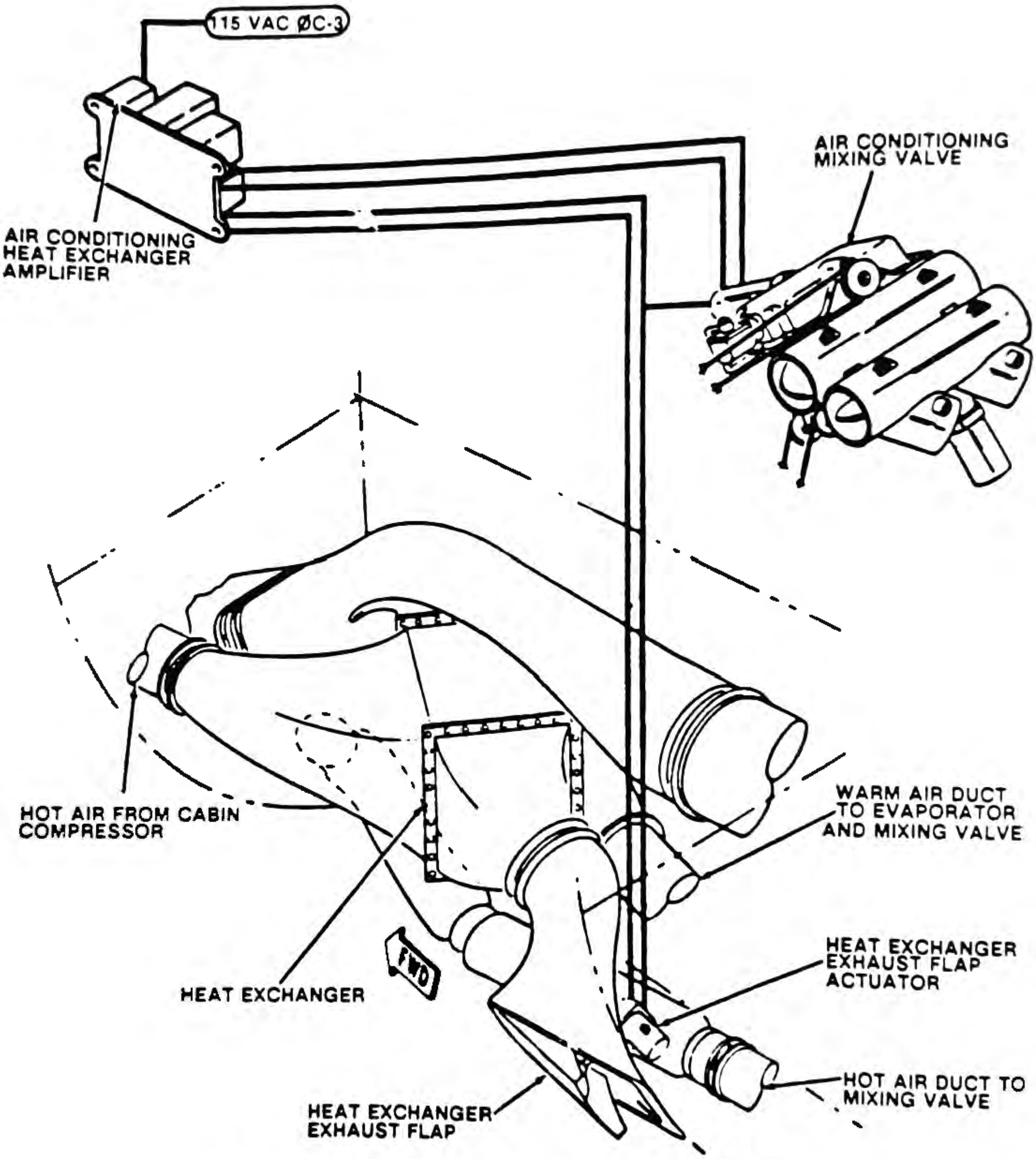
B. Component Description

(1) Air-Conditioning Heat Exchanger

The air-conditioning heat exchanger, an air-to-air type of exchanger, reduces the heat of the hot air supply from the cabin compressors to form the warm air supply One heat exchanger is provided for each air-conditioning system. The heat exchanger is a rectangular-shaped, aluminum alloy unit open to airflow on four sides. The heat exchanger core consists of layers of corrugated passages separated and sealed by aluminum sheets. Every corrugated layer is installed at 90 degrees to the flow line of the preceding layer. This permits two independent airflows through the exchanger with no leakage between the two flows. Cooling ram air flows through one set of passages and hot air from the cabin compressors flows through the other set.

(2) Air-Conditioning Heat Exchanger Exhaust Flap Assembly

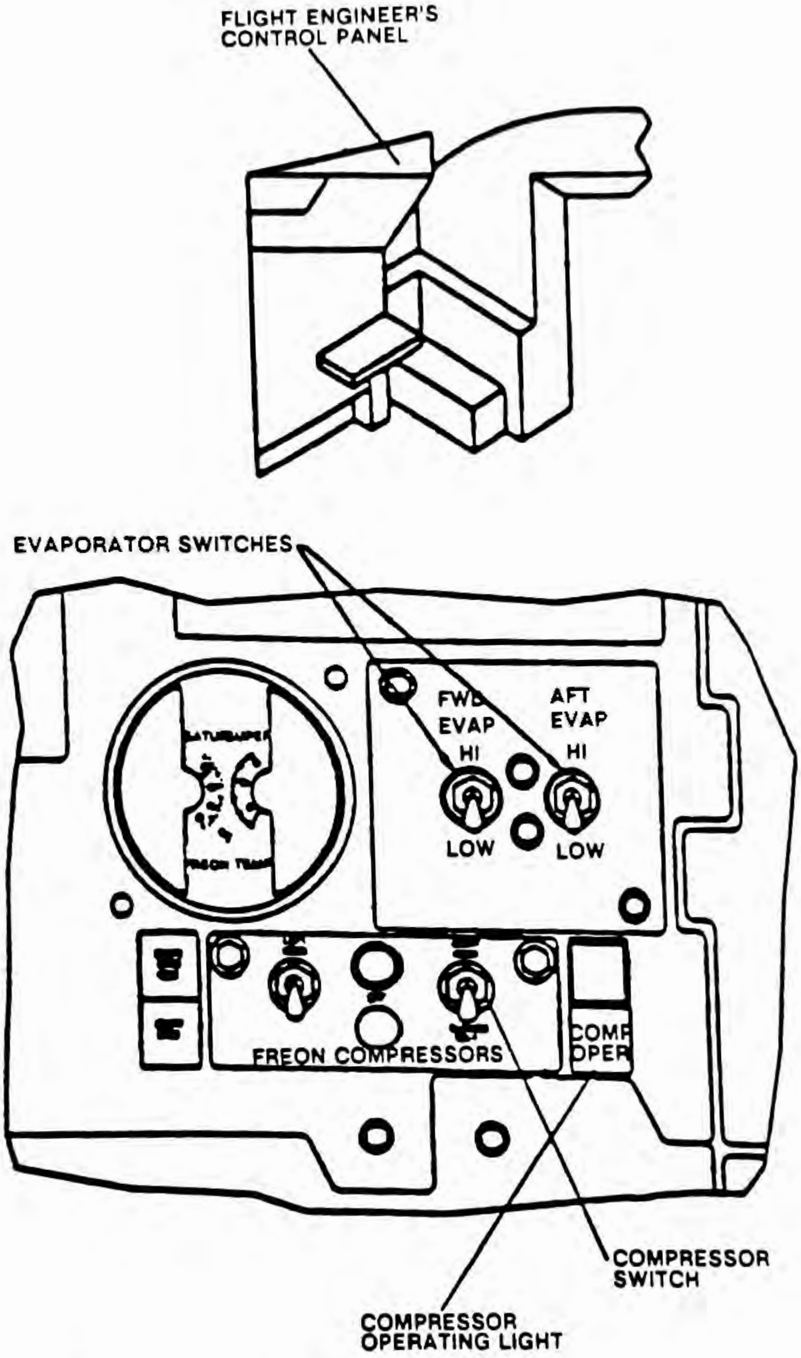
A heat exchanger exhaust flap is incorporated in the exhaust duct of each heat exchanger. The flaps are installed flush with the fuselage skin and are located on each side of the fuselage nose section. The entire assembly is removable to allow access to components that are located in the air-conditioning tunnel, adjacent to the nosewheel well. The flap is hinged at two places and is connected by linkage to an electrically operated actuator.


115 VAC ØC-3
AIR CONDITIONING HEAT EXCHANGER AMPLIFIER
AIR CONDITIONING MIXING VALVE
HOT AIR FROM CABIN COMPRESSOR
WARM AIR DUCT TO EVAPORATOR AND MIXING VALVE
FWD
HEAT EXCHANGER
HEAT EXCHANGER EXHAUST FLAP ACTUATOR
HOT AIR DUCT TO MIXING VALVE
HEAT EXCHANGER EXHAUST FLAP

AIR-CONDITIONING HEAT EXCHANGER EXHAUST FLAP CONTROL COMPONENTS

FTX80380

Figure 21-64



REFRIGERATION SYSTEM CONTROLS

FTX80383

Figure 21-68

actuator. Movement of the wiper arm alters the electrical resistance of the potentiometer and the bridge becomes unbalanced. The resulting signal from the bridge is amplified to a value that can operate the appropriate control relay within the amplifier. Which of the two control relays is operated depends upon whether the temperature control system demands an increase or a decrease in air temperature.

(3) When the heat exchanger exhaust flap is positioned to permit an airflow across the heat exchanger that is consistent with the temperature demands of the system, the control bridge again becomes balanced, the signal to the air-conditioning heat exchanger amplifier stops, and the relay drops out to open the load circuit to the actuator motor.

13. Refrigeration System - Description and Operation

A. General

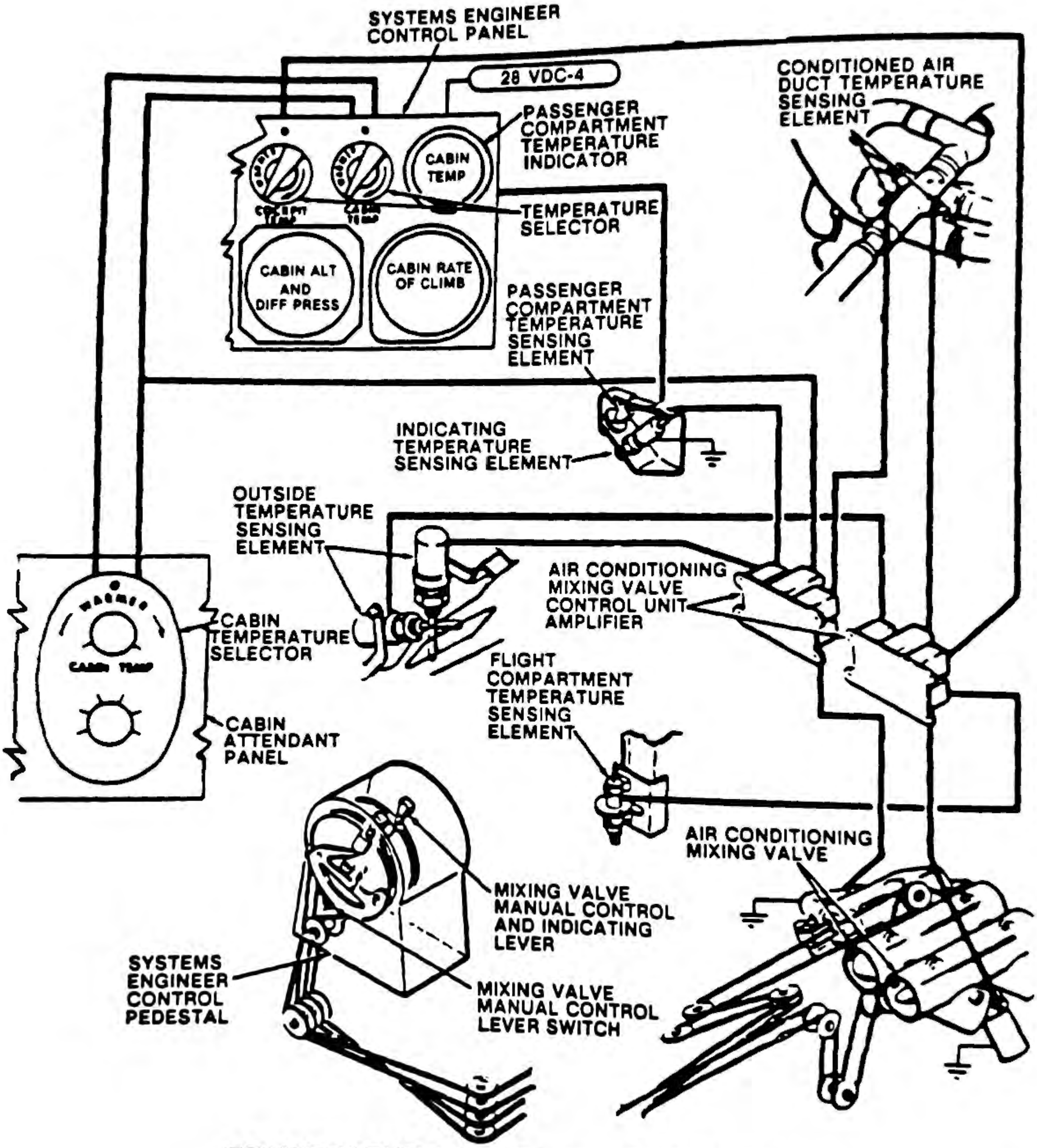
(1) A supplemental air conditioning system is used in lieu of the original Douglas right-hand refrigeration system, which is partially removed and deactivated. The system consists of a compressor/condenser module, two remotely located evaporator units, associated switches, and hoses. This system is independent of the aircraft left refrigeration system, and supplies cool air to the cockpit only.

(2) The refrigeration cycle performs the cooling and dehumidification process of cabin air. In this type of system, cabin air is passed over the evaporator, and is cooled as heat is absorbed from this air by low pressure refrigerant -12 passing through the evaporator (Figure 21-66). Only refrigerant -12 is used to service the system. The refrigerant is then compressed to a higher pressure gas and delivered to the refrigerant condenser. At the condenser, heat which has been absorbed by the refrigerant is transferred to cooling air, passing through the condenser from the nose wheel well. The condensed refrigerant is then returned to the evaporator, completing the cycle.

B. Component Description

(1) Compressor/Condenser Module

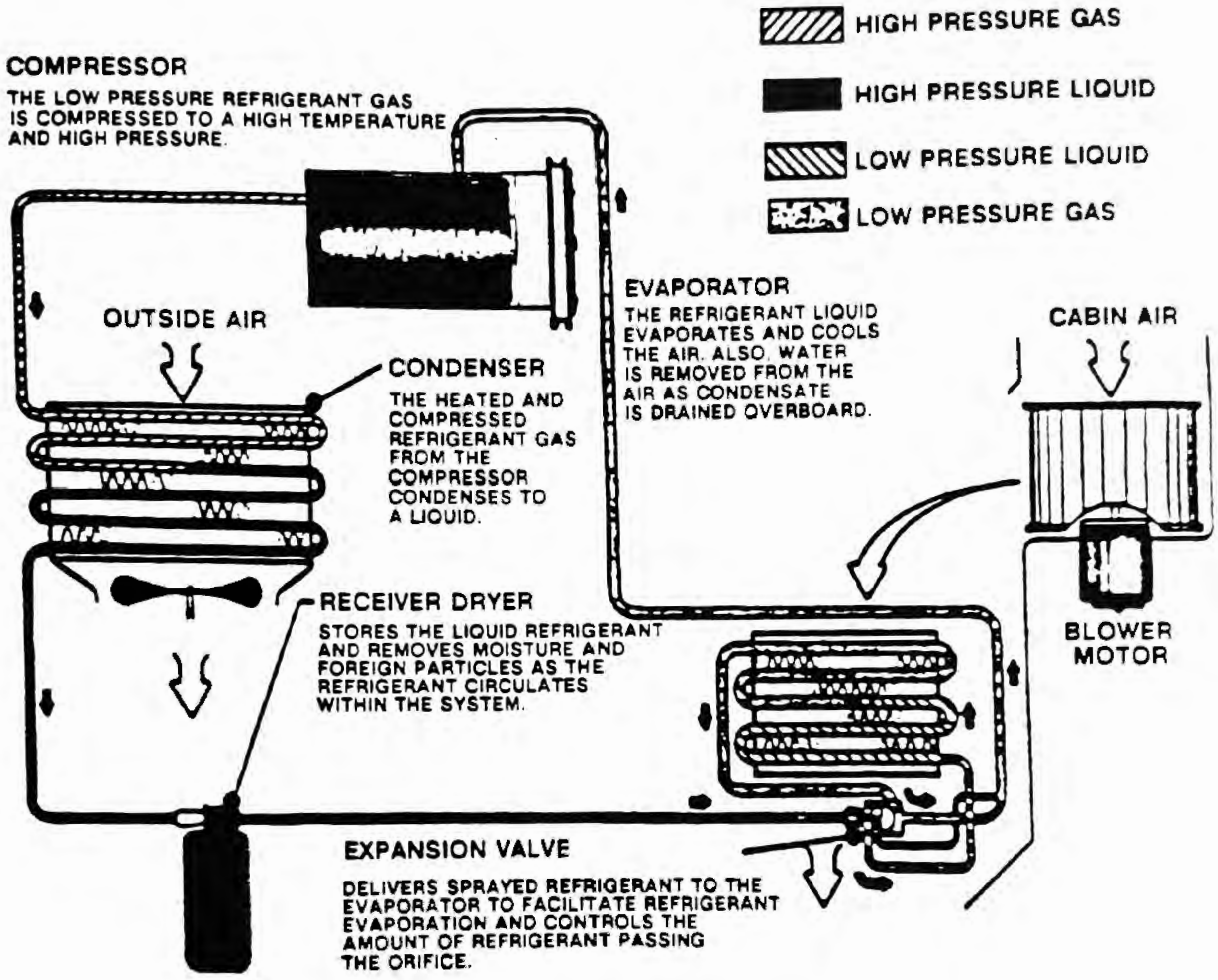
(a) The compressor/condenser module consists of the following units: compressor assembly, motor assembly, coil assembly (condenser), and receiver/dryer assembly. This module is located in the right utility tunnel at the approximate location of the previous condenser unit. The freon compressor is a 5 cylinder rotary piston type compressor with a anti-liquid slugging design that takes low pressure gaseous freon and converts it to high pressure gaseous freon. Lubrication is supplied by an internal cavity within the compressor using refrigerant oil. The compressor is driven by a three phase 115 vac 400 Hz electric motor powered by AC Bus 4. The compressor drive motor power relay is located beneath the drive motor and receives power from the 28 vdc Radio bus 3. The compressor drive belt is a high strength positive grip synchro-cog type belt.


SYSTEMS ENGINEER CONTROL PANEL
28 VDC-4
CONDITIONED AIR DUCT TEMPERATURE SENSING ELEMENT
PASSENGER COMPARTMENT TEMPERATURE INDICATOR
CABIN TEMP
COCKPIT TEMP
CABIN TEMP
TEMPERATURE SELECTOR
CABIN ALT AND DIFF PRESS
CABIN RATE OF CLIMB
PASSENGER COMPARTMENT TEMPERATURE SENSING ELEMENT
INDICATING TEMPERATURE SENSING ELEMENT
OUTSIDE TEMPERATURE SENSING ELEMENT
AIR CONDITIONING MIXING VALVE CONTROL UNIT AMPLIFIER
WARMER
CABIN TEMP
CABIN TEMPERATURE SELECTOR
CABIN ATTENDANT PANEL
FLIGHT COMPARTMENT TEMPERATURE SENSING ELEMENT
AIR CONDITIONING MIXING VALVE
MIXING VALVE MANUAL CONTROL AND INDICATING LEVER
SYSTEMS ENGINEER CONTROL PEDESTAL
MIXING VALVE MANUAL CONTROL LEVER SWITCH

TEMPERATURE CONTROL COMPONENTS

FTX80385

Figure 21-70



COMPRESSOR

THE LOW PRESSURE REFRIGERANT GAS IS COMPRESSED TO A HIGH TEMPERATURE AND HIGH PRESSURE.

EVAPORATOR

THE REFRIGERANT LIQUID EVAPORATES AND COOLS THE AIR. ALSO, WATER IS REMOVED FROM THE AIR AS CONDENSATE IS DRAINED OVERBOARD.

CONDENSER

THE HEATED AND COMPRESSED REFRIGERANT GAS FROM THE COMPRESSOR CONDENSES TO A LIQUID.

RECEIVER DRYER

STORES THE LIQUID REFRIGERANT AND REMOVES MOISTURE AND FOREIGN PARTICLES AS THE REFRIGERANT CIRCULATES WITHIN THE SYSTEM.

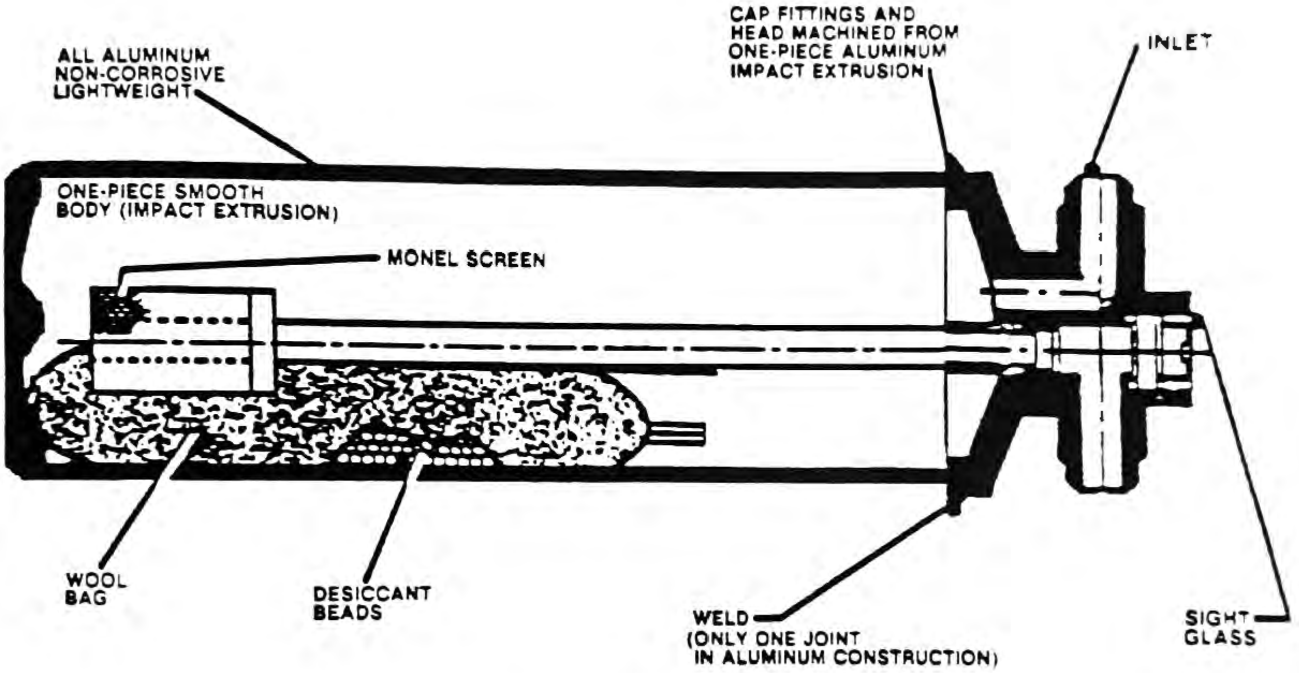
EXPANSION VALVE

DELIVERS SPRAYED REFRIGERANT TO THE EVAPORATOR TO FACILITATE REFRIGERANT EVAPORATION AND CONTROLS THE AMOUNT OF REFRIGERANT PASSING THE ORIFICE.

REFRIGERATION SYSTEM OPERATION

FTX80374

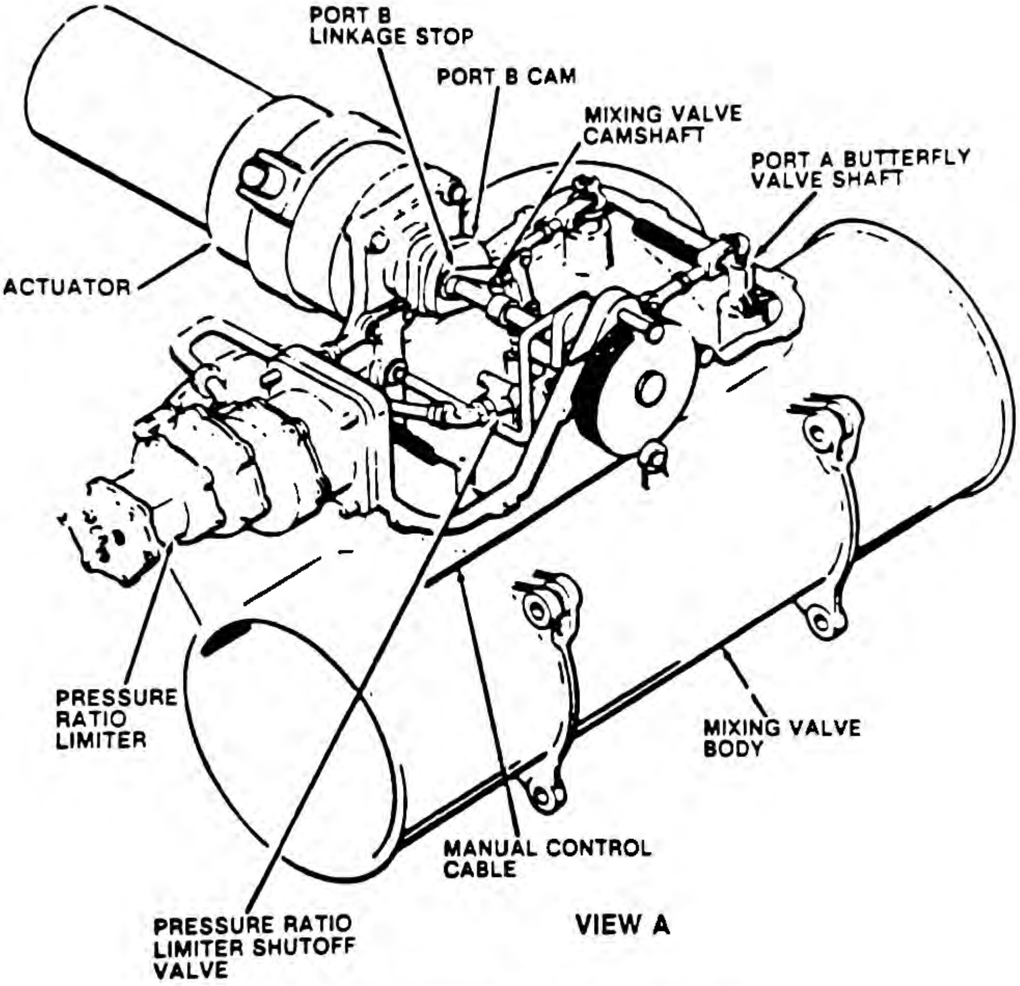
Figure 21-66



RECEIVER/DRYER WITH DESICCANT IN WOOL FELT BAG

FTX80382

Figure 21-67



AIR CONDITIONING MIXING VALVE
EXTERNAL VIEW

FTX80387

Figure 21-72

(3) Refrigeration Controls

The refrigeration controls are located on the flight engineer's control panel, and are incorporated with the aircraft primary refrigeration system controls. The freon compressor control switch is installed in place of the original right freon comp switch. This is a three position switch: RIGHT NORM, BLOWER ONLY, and OFF. Also mounted on the control panel is a two position switch for each evaporator (fwd and aft) labeled HI and LOW.

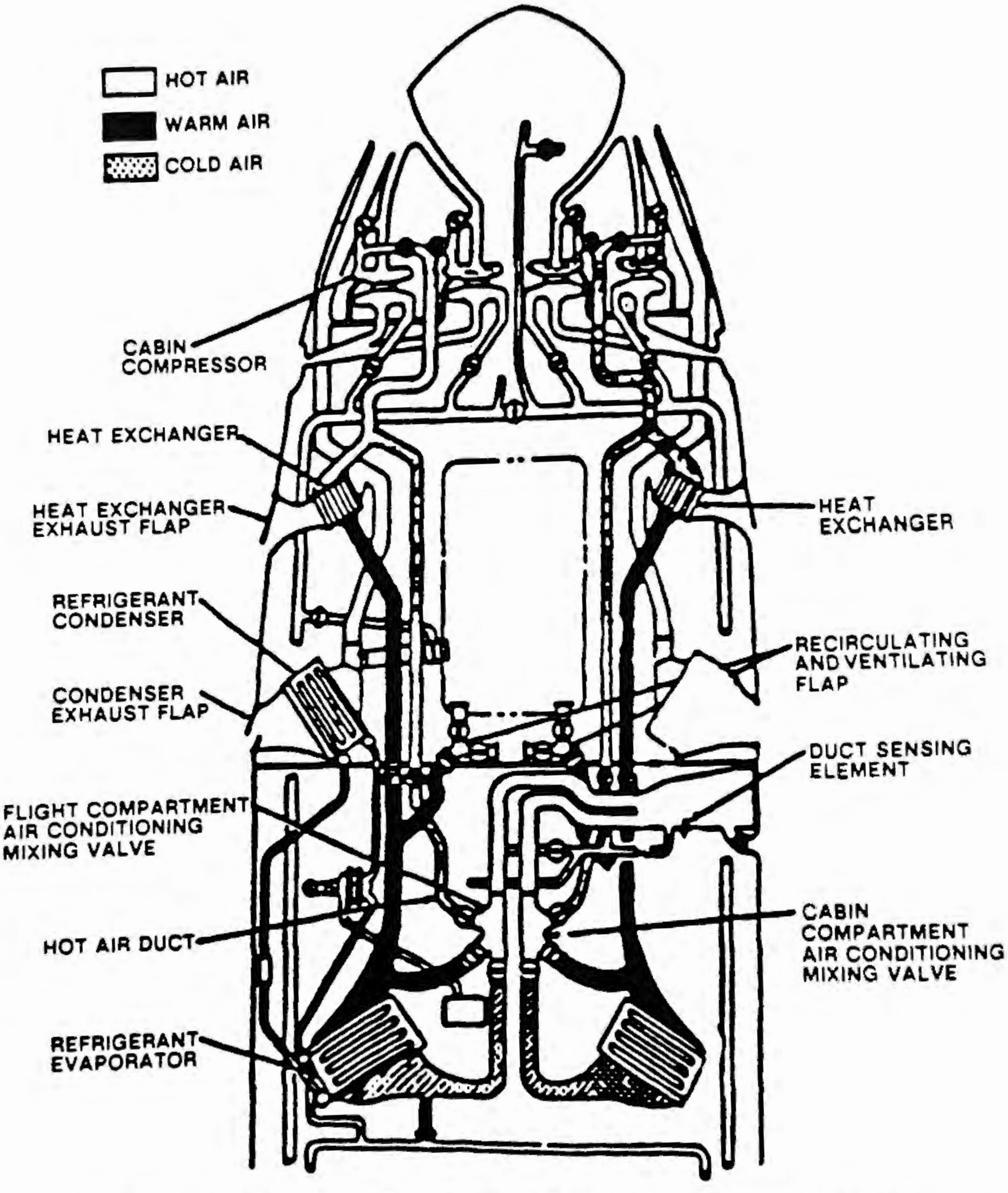
(4) System Operation (Figure 21-68)

The refrigeration system is controlled from the air conditioning control panel at the flight engineer's position. When the freon compressor switch is in NORM position the freon compressor will supply liquid refrigerant to both evaporators; the evaporator motors will operate at the selected speed, hi or low, and the compressor oper light will illuminate. With the compressor switch placed in the BLOWERS ONLY position: the compressor will be off, and the evaporator motors will be operating at the speed selected by the respective evaporator blower switch.

14. Temperature Control - Description and Operation

A. General

(1) The temperature control system is provided to maintain the desired temperature in the cabin compartment and flight compartment. Fresh air from the ram air scoops is heated by compression in the cabin compressors and can be used as is, or cooled by the air conditioning heat exchanger or further cooled by the refrigeration system. These three sources of air are connected to the three butterfly valve-controlled inlets of the air conditioning mixing valve (Figure 21-69). The temperature control system components position the mixing valve to flow the proper amount of hot, warm, or cold air as required for cabin and flight compartment air conditioning. The relative position of the mixing valve is a function in the control of the refrigeration system, heat exchanger cooling air flow, cabin compressors, and recirculating fans.



TEMPERATURE CONTROL MECHANICAL SCHEMATIC

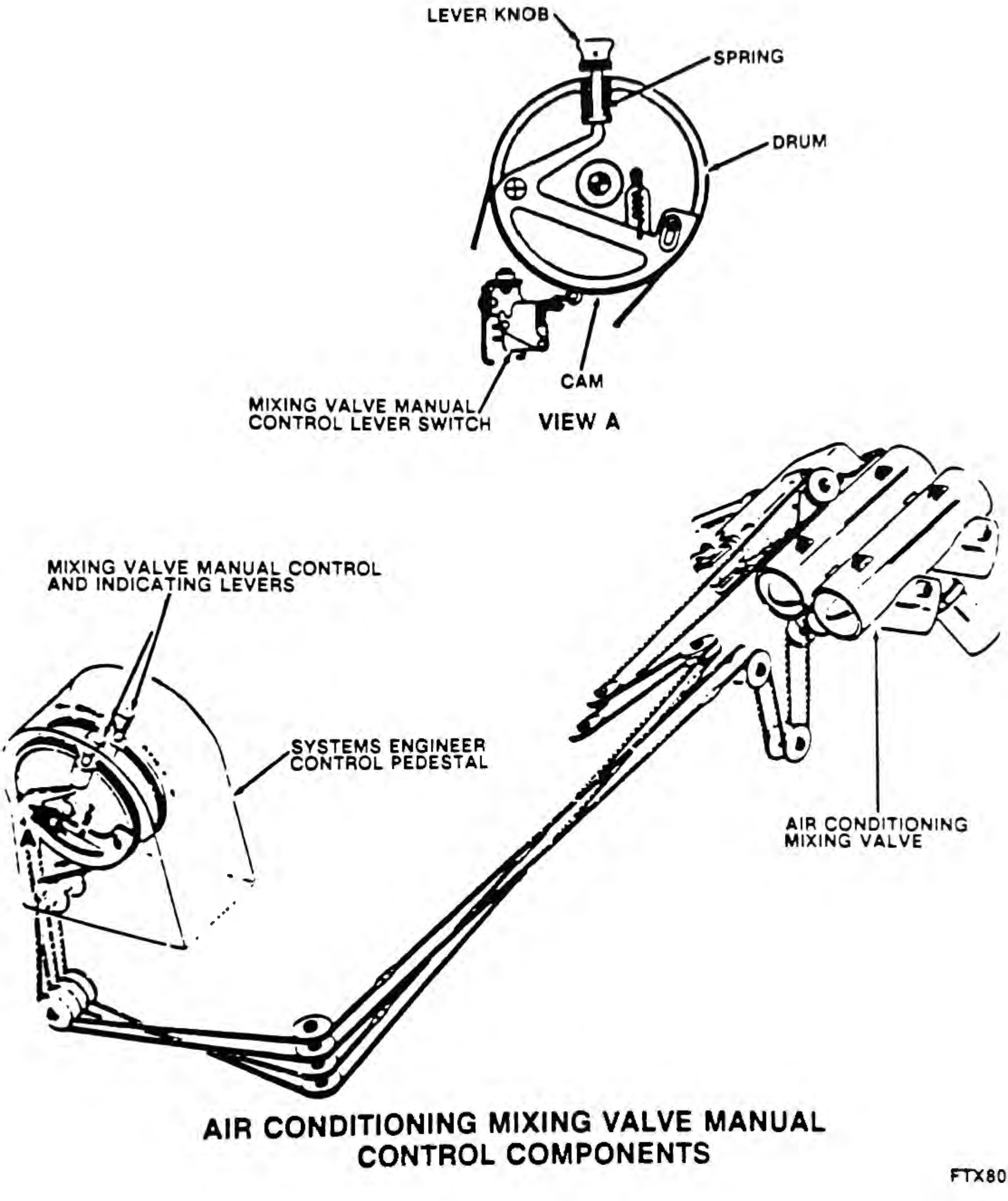
FTX80384

Figure 21-69

(2) Because of the volume difference between the two compartments, a large percentage of conditioned air supplied by the flight compartment temperature control system is directed into the cabin compartment distribution ducts. Each system consists of an air conditioning mixing valve, pressure ratio limiter and shutoff valve, air conditioning mixing valve control unit, temperature selector, compartment (cabin or flight temperature sensing element), conditioned air duct temperature sensing element, outside temperature sensing element, and air conditioning mixing valve (temperature control) manual control lever switch. (Figure 21-70). The manual control lever switch is located in the flight engineer's control pedestal and is actuated by the mixing valve manual control and indicating lever knob. The temperature control system functions to amplify and convert error signals between the sensing elements and the temperature selector and to provide direction signals and power to position the air conditioning mixing valve.

(3) Either temperature control system can be operated manually or automatically. During automatic operation, the mixing valve is positioned by a motor driven actuator, and the relative position is indicated by the mixing valve manual control and indicating lever on the flight engineer's control pedestal. The lever is mechanically connected to the mixing valve by cables (Figure 21-71). When the motor driven actuator is deenergized and the clutch disengaged by pulling the lever up, the same lever becomes the manual control lever for the system. By observing the cabin temperature indicator on the flight engineer's control panel, the operator can position the air conditioning mixing valve manual control and indicating lever to control and maintain the desired temperature.

(4) The pressure ratio limiter and associated shutoff valve are mounted on the air conditioning mixing valve. The pressure ratio limiter prevents the mixing valve from imposing excessive back pressure on the cabin compressors which could result in a stall condition. The pressure ratio limiter overrides the temperature control system demands to close port C when the back pressure becomes excessive.


LEVER KNOB
SPRING
DRUM
CAM
MIXING VALVE MANUAL CONTROL LEVER SWITCH
VIEW A
MIXING VALVE MANUAL CONTROL AND INDICATING LEVERS
SYSTEMS ENGINEER CONTROL PEDESTAL
AIR CONDITIONING MIXING VALVE

AIR CONDITIONING MIXING VALVE MANUAL CONTROL COMPONENTS

FTX80386

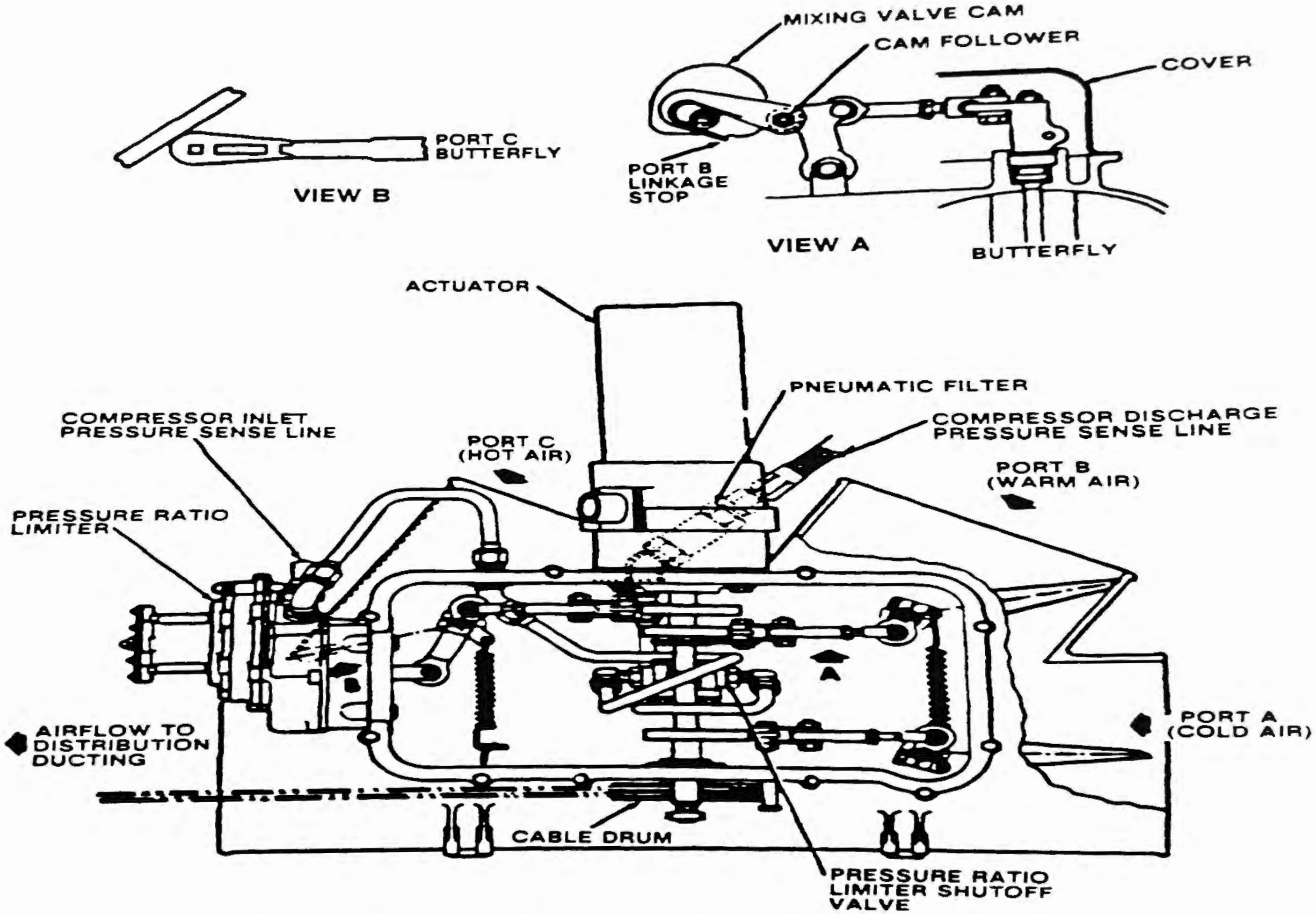
Figure 21-71

B. Component Description

(1) Air Conditioning Mixing Valve

(a) The air conditioning mixing valve (Figure 21-72), one for each temperature control system, mixes hot, warm, and cold air to maintain the desired temperature for the applicable compartment. Each valve can be operated automatically by a motor driven actuator, or manually by a cable system. Both mixing valves are located in the air conditioning accessory compartment.

(b) The mixing valve incorporates three inlet ports and one outlet port. The inlet ports of the valve are referred to as ports A, B, and C (Figure 21-73). Port A is the cold air port and receives air from the evaporator of the refrigeration system. Port B is the warm air port and receives air from the air conditioning heat exchanger. Port C receives air directly from the cabin compressors. The mixing valve actuator, pressure ratio limiter, and pressure ratio limiter shutoff valve are mounted on the body of the valve. A butterfly valve installed at each of the three inlet ports is actuated by a cam and linkage arrangement. All cams are mounted on a single shaft. Limit switches, actuated by camshaft rotation, are used to limit camshaft rotation between 0 and 270 degrees, perform a function in recirculation fan control, and stop and start the refrigeration system. The butterfly valve of each inlet port is spring loaded towards the closed position to provide positive engagement of the valve linkage with the cam. A mechanical stop in the form of a hook is mounted on port B butterfly linkage. The hook portion of the stop engages the camshaft during manual operation if the butterfly tends to overtravel. A cam is also provided for operation of the pressure ratio limiter shutoff valve.



AIR CONDITIONING MIXING VALVE SCHEMATIC

FTX80388

Figure 21-73

(11) Cabin Compartment Temperature Indicating Components

(a) An indicator and a temperature sensing element are provided to monitor cabin compartment temperatures. The temperature indicator is located on a panel in the flight compartment. The temperature indicating sensing element is installed adjacent to the cabin compartment temperature sensing element on the aft drop ceiling panel.

(b) The temperature indicator is a ratiometer operating on the unbalanced bridge principle, and the temperature sensing element is the variable leg of the bridge. Resistance of the element determines the unbalance of the bridge, which causes the indicator needle to be deflected to indicate temperature. The armature of the indicator, with needle attached has two coils turning in the air gap of a permanent magnet. A galvanometer and the restoring coil are in series with one leg of the bridge and oppose the motion of the deflecting coil. Three hairsprings connect the coils to the bridge circuit.

C. Systems Operation

(1) The temperature control system functions to position the mixing valve so that hot, warm, and cold air directed to the inlet ports of the air conditioning mixing valve, proportionally mixed to maintain a selected temperature in the occupied areas of the airplane.

(2) The total amount of conditioned (temperature-controlled) air from the right air conditioning system is routed into the cabin compartment conditioned air distribution ducting. A portion of the conditioned air from the left air conditioning system is routed to the flight compartment conditioned air distribution ducting. The remaining air is added to the cabin compartment supply. However, each temperature control system functions to maintain the temperature selected for the corresponding compartment. If temperature demands for the flight compartment are higher than the cabin compartment, the flight compartment temperature control system positions the mixing valve of the left system to deliver the required higher temperature. The higher temperature air is also added to the cabin compartment supply. The cabin compartment temperature control system senses

(c) The mixing valve camshaft has 270 degrees of rotation, each butterfly valves moves through an arc of 45 degrees. The 0-degree position of the camshaft represents full cold position. Full clockwise rotation (looking from the cable drum end of the camshaft), which is 270 degrees clockwise from the 0-degree position, represents the full hot position. As the camshaft is rotated away from the 0-degree position, port A butterfly valve (cold port) begins to close and port B butterfly valve (warm port) begins to open. Port A is fully closed at 67.5 degrees of camshaft rotation and port B is fully open. Port B remains fully open from 67.5 degrees of 97.5 degrees of camshaft rotation. At 97.5 degrees of camshaft rotation. At 97.5 degrees of camshaft rotation, port B begins to close and port C (hot port) begins to open and is fully open at 142 degrees. Port B is fully closed at 165 degrees. Port C butterfly valve remains fully open from 142 degrees through 158 1/2 degrees of camshaft rotation. As the camshaft continues to rotate from 158 1/2, degrees port C butterfly valve moves towards the closed position and at 270 degrees of camshaft rotation, port C butterfly valve is 44.5 degrees. It is possible to have either port A or port B wide open individually, or to have two of the three adjacent ports open in varying degrees (port A and B partly open or port B and C partly open). Ports A and C cannot be open at the same time, that is hot and cold air cannot be mixed. The actuator consists of an output shaft connected to an electric motor through gearing and a magnetic clutch, and is mounted on the mixing valve with the serrated output shaft meshed with the mixing valve camshaft.

(2) Air Conditioning Mixing Valve Manual Control and Indicating Levers

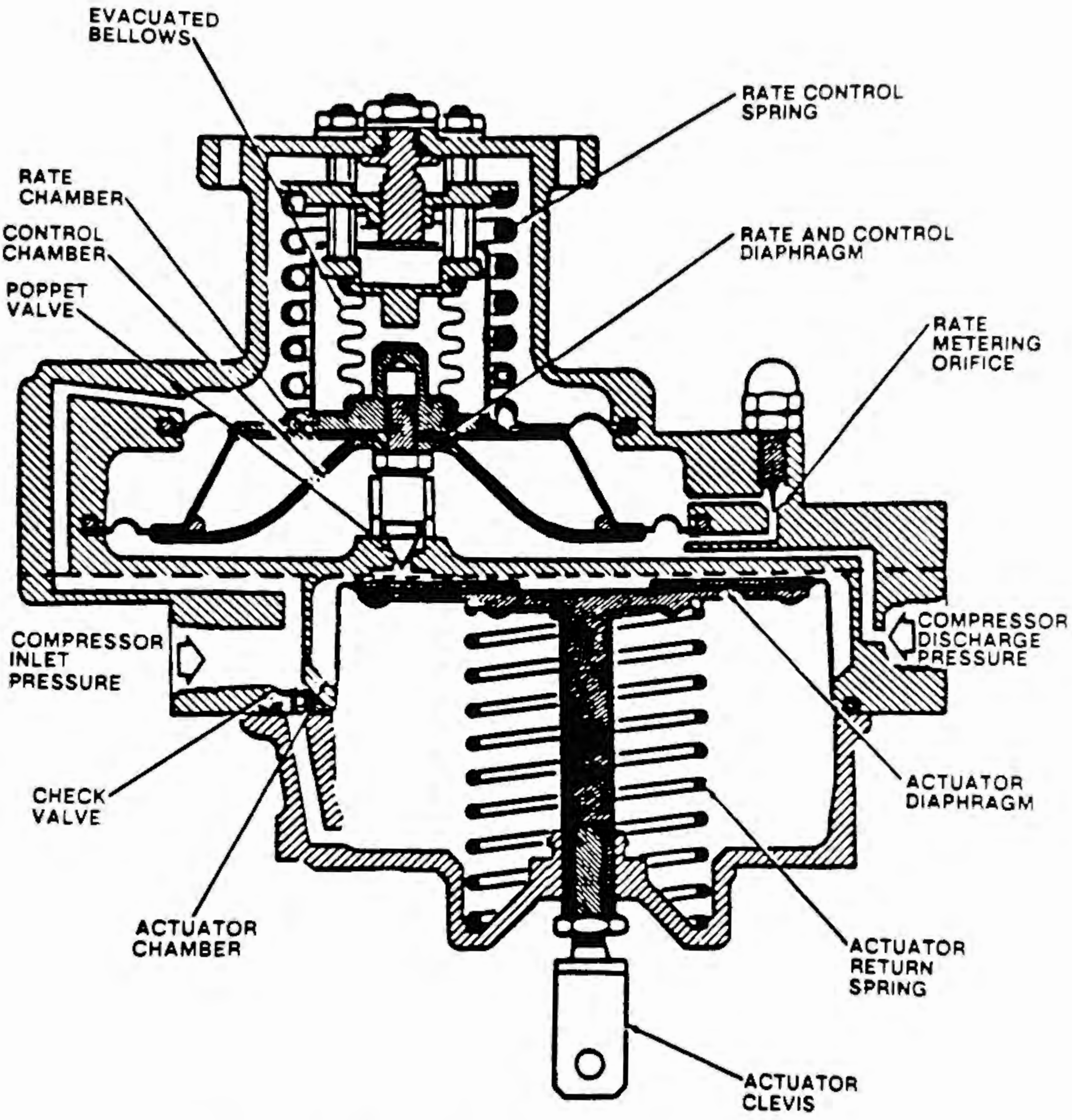
(a) Two levers provide a means of manually overriding automatic operation of the mixing valve, and also indicates mixing valve positions during both automatic and manual operation (Figure 21-70). The air conditioning mixing valve manual control and indicating levers for cabin and flight compartment control are located side by side in the flight engineer's control pedestal. Each lever is pinned to a shaft which is interconnected to a drum and cam which rotate freely on a shaft in the control pedestal. The drums in the control pedestal and the drums of the mixing valves are connected by a cable system.

(b) The mixing valve manual control and indicating lever is spring loaded to a retracted position within a housing which is part of the cable drum assembly. A cam, also attached to the cable drum, is spring loaded against the control lever. Moving the control lever up from the normal position permits the spring loaded cam to follow the lever. The cam actuates the mixing valve manual control lever switch which controls power to the magnetic clutch and the mixing valve actuator. Since the manual control levers are connected to the mixing valve camshaft, movement of the levers in the quadrant gives corresponding movement to the mixing valve butterfly shafts. The manual control levers can be locked in any position by rotating the knob 90 degrees and lowering the knob into the quadrant.

(3) Pressure Ratio Limiter

(a) The pressure ratio limiter is a differential pressure-sensing diaphragm-type, actuator bolted directly to each air conditioning mixing valve (Figure 21-73). The purpose of the limiter is to prevent an excessive pressure differential across the cabin compressors which could cause a compressor stall. The actuator clevis of the limiter is connected to the crank of port C butterfly valve. Pressure sensing lines are connected to the pressure ratio limiter from the pressure ratio limiter shutoff valve and from the cabin compressor discharge ducts.

(b) The limiter (Figure 21-74) consists of a housing containing an actuator diaphragm assembly, a rate and control diaphragm assembly, an evacuated bellows, a poppet valve, an actuator clevis, an actuator return spring and a rate control spring. The housing forms the actuator and control chambers, and has inter-connecting passages. A check valve is mounted in a passage between the forward section of the actuator chamber and compressor inlet line, and a rate-metering orifice is incorporated between the rate and control chambers.



PRESSURE RATIO LIMITER SCHEMATIC

FTX80389

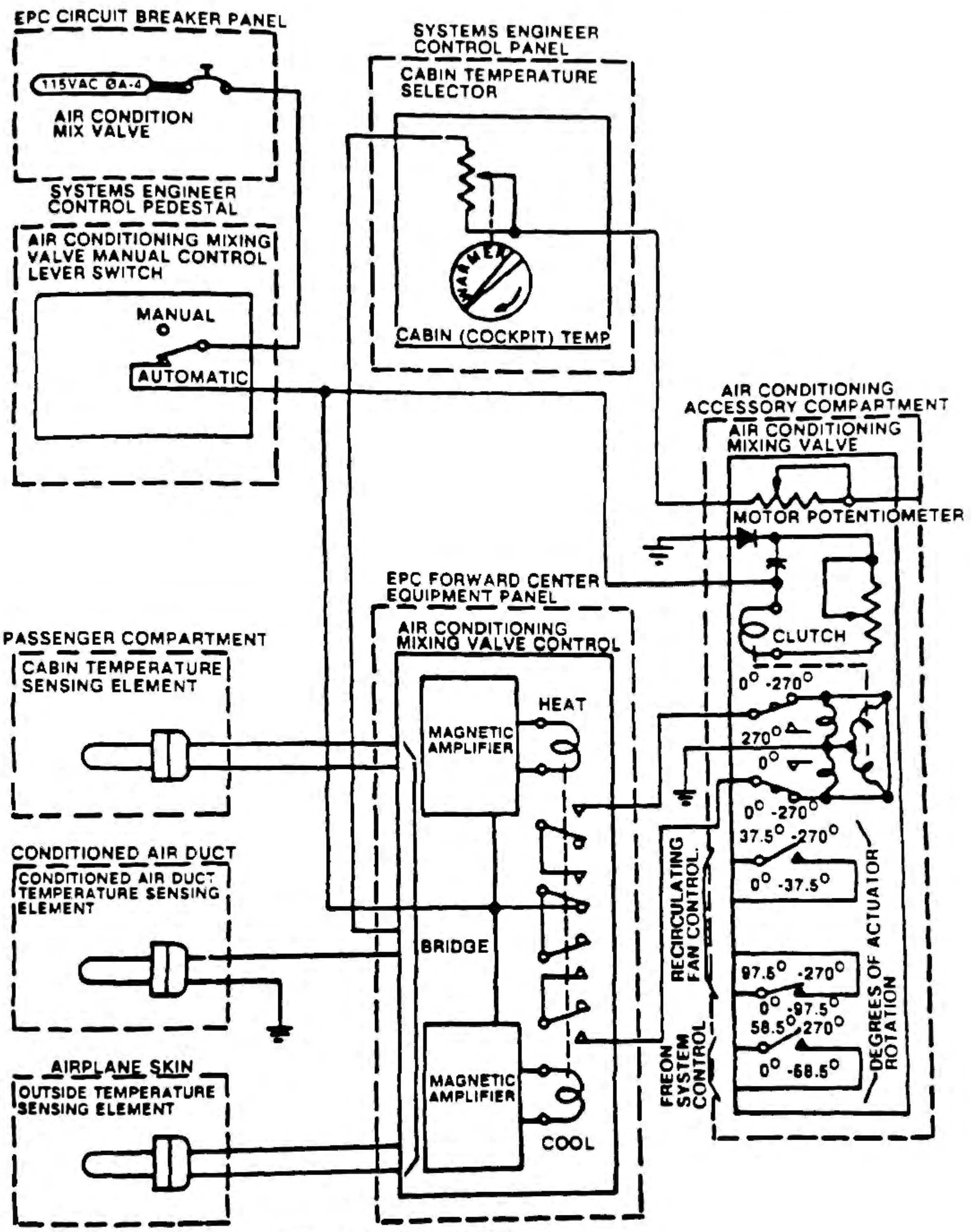
Figure 21-74

(c) A change in pressure differential between the compressor discharge pressure and compressor inlet pressure is sensed across the rate and control diaphragm assembly of the limiter, provided the pressure ratio limiter shutoff valve is open. The diaphragm assembly moves in response to the change, causing the poppet valve to modify the rate of airflow from the compressor discharge pressure connection to the actuator chamber. The changed rate of airflow causes a change in pressure differential across the actuator diaphragm assembly, moving the actuator diaphragm assembly, and extending or retracting the actuator clevis which limits the travel of port C butterfly valve. When air pressure decreases at the compressor inlet pressure-sensing port, the bellows expands to exert a force against the control diaphragm assembly. Under these conditions a greater pressure differential between the compressor discharge pressure and compressor inlet pressure connections is required to extend the actuator clevis. When the compressor inlet pressure increases, less pressure differential is required. This effect compensates for the variations in compressor inlet pressure caused by altitude and airplane speed.

(4) Pressure Ratio Limiter Shutoff Valve

(a) A pressure ratio limiter shutoff valve mounted on each mixing valve housing is a poppet-type valve which is actuated by a cam installed on the air conditioning mixing valve camshaft. The purpose of the valve is to permit the pressure ratio limiter to sense compressor discharge pressure only during port C back pressure range of the mixing valve operation. The valve incorporates an inlet and outlet port, a spring-loaded actuating rod ball and seat, and the required drilled passages to pass airflow through the valve.

(b) The valve is closed from 0 to approximately 130 degrees of mixing valve camshaft rotation. At approximately 130 degrees the valve begins to open, actuated by the mixing valve camshaft as it rotates towards port C range. At approximately 165 degrees the valve is wide open, and remains open through the remainder of camshaft clockwise movement. When the valve is open, compressor discharge air pressure sensed upstream of port B of the mixing valve is ported to the pressure ratio limiter.


EPC CIRCUIT BREAKER PANEL
115VAC ØA-4
AIR CONDITION MIX VALVE
SYSTEMS ENGINEER CONTROL PEDESTAL
AIR CONDITIONING MIXING VALVE MANUAL CONTROL LEVER SWITCH
MANUAL
AUTOMATIC
SYSTEMS ENGINEER CONTROL PANEL
CABIN TEMPERATURE SELECTOR
WARMER
CABIN (COCKPIT) TEMP
AIR CONDITIONING ACCESSORY COMPARTMENT
AIR CONDITIONING MIXING VALVE
MOTOR POTENTIOMETER
CLUTCH
0° -270°
270°
0°
0° -270°
37.5° -270°
0° -37.5°
97.5° -270°
0° -97.5°
58.5° -270°
0° -58.5°
DEGREES OF ACTUATOR ROTATION
RECIRCULATING FAN CONTROL
FREON SYSTEM CONTROL
EPC FORWARD CENTER EQUIPMENT PANEL
AIR CONDITIONING MIXING VALVE CONTROL
MAGNETIC AMPLIFIER
HEAT
BRIDGE
MAGNETIC AMPLIFIER
COOL
PASSENGER COMPARTMENT
CABIN TEMPERATURE SENSING ELEMENT
CONDITIONED AIR DUCT
CONDITIONED AIR DUCT TEMPERATURE SENSING ELEMENT
AIRPLANE SKIN
OUTSIDE TEMPERATURE SENSING ELEMENT

NOTE: PASSENGER COMPARTMENT SYSTEM SHOWN.
FLIGHT COMPARTMENT SIMILAR EXCEPT AS NOTED.

TEMPERATURE CONTROL ELECTRICAL SCHEMATIC

FTX80390

Figure 21-76

(5) Temperature Selector

There are two temperature selectors located in the flight compartment, one for the cabin compartment system and one for the flight compartment system. Each selector is a variable resistor which forms one leg of a balanced bridge circuit that functions with the corresponding air conditioning mixing valve control unit to position the mixing valve.

(6) Compartment Temperature Sensing Element

Two compartment temperature sensing elements, one for the cabin compartment and one for the flight compartment, sense the temperature of the air in the corresponding area. The flight compartment sensing element is located in the forward face of the footrest provided at the right hand pilot's position. The cabin compartment sensing element is installed on the forward face of the aft drop ceiling. The temperature sensing elements have a negative temperature coefficient (increase in temperature, decrease in resistance). A change in temperature in either area changes the resistance of the corresponding element. Since the element forms a variable resistance leg in the corresponding temperature control bridge circuitry, the bridge becomes unbalanced with any change in sensing element resistance.

(7) Outside Temperature Sensing Element

Two outside temperature sensing elements, one for the cabin compartment and one for the flight compartment temperature control system, sense the temperature of the air outside the airplane. The elements are located adjacent to each other in a common well in the lower surface of the fuselage. Changes in outside air temperature affect the temperature of the sensing element and consequently the electrical resistance. Since each element forms a variable resistance leg in the corresponding temperature control bridge circuitry, the bridge becomes unbalanced with any change in sensing element resistance.

(8) Conditioned Air Duct Temperature Sensing Element

Two conditioned air duct temperature sensing elements, one for the cabin compartment system and one for the flight compartment system, sense the temperature of the conditioned air as it leaves the mixing valves. The elements are located in the main distribution ducts of each compartment, downstream of the mixing valves. A change in duct temperature affects the temperature of the element and consequently the electrical resistance. Since the element forms a variable resistance leg in corresponding temperature control bridge circuitry, the bridge becomes unbalanced with any change of sensing element resistance.

(9) Air Conditioning Mixing Valve Control Unit

(a) The air conditioning mixing valve control unit, one for each temperature control system, consists of five cams mounted on a common base and located in the forward center equipment panel. The control unit mixes and amplifies signals received from the temperature selector and sensing elements and provides an operating signal to position the air conditioning mixing valve.

(b) The main components of the control unit are two magnetic amplifiers, two control relays, radio noise filters, and the necessary resistors and circuitry. Each magnetic amplifier controls a corresponding control relay. Each control relay is connected to an individual field of the mixing valve actuator motor. The direction of motor rotation depends upon which control relay is energized, as determined by the magnetic amplifier and polarity of the bridge signal. When movement of the mixing valve actuator has adjusted the resistance of a follow-up potentiometer (within the actuator) to balance the bridge circuitry, the operating magnetic amplifier becomes desaturated, allowing the control relay to drop out, opening the power circuit to the actuator.

(10) Air Conditioning Mixing Valve Manual Control Lever Switch

Two air conditioning mixing valve manual control lever switches, one for each temperature control system, are located in the flight engineer's control pedestal. Each switch is actuated by the corresponding mixing valve manual control lever knob and cam arrangement and functions to deenergize the mixing valve actuator and magnetic clutch during manual operation.

(2) Cabin Pressure Indication

The pressure control system is monitored by the cabin altitude and differential pressure indicator and the cabin rate-of-climb indicator. A cabin low-pressure warning horn sounds intermittently if the cabin pressure altitude reaches approximately 10,000 feet.

(3) Operation

The cabin pressure control system and cabin pressure indication system are functionally independent. Operation of these systems is described individually under their respective titles.

16. Cabin Pressure Control - Description and Operation

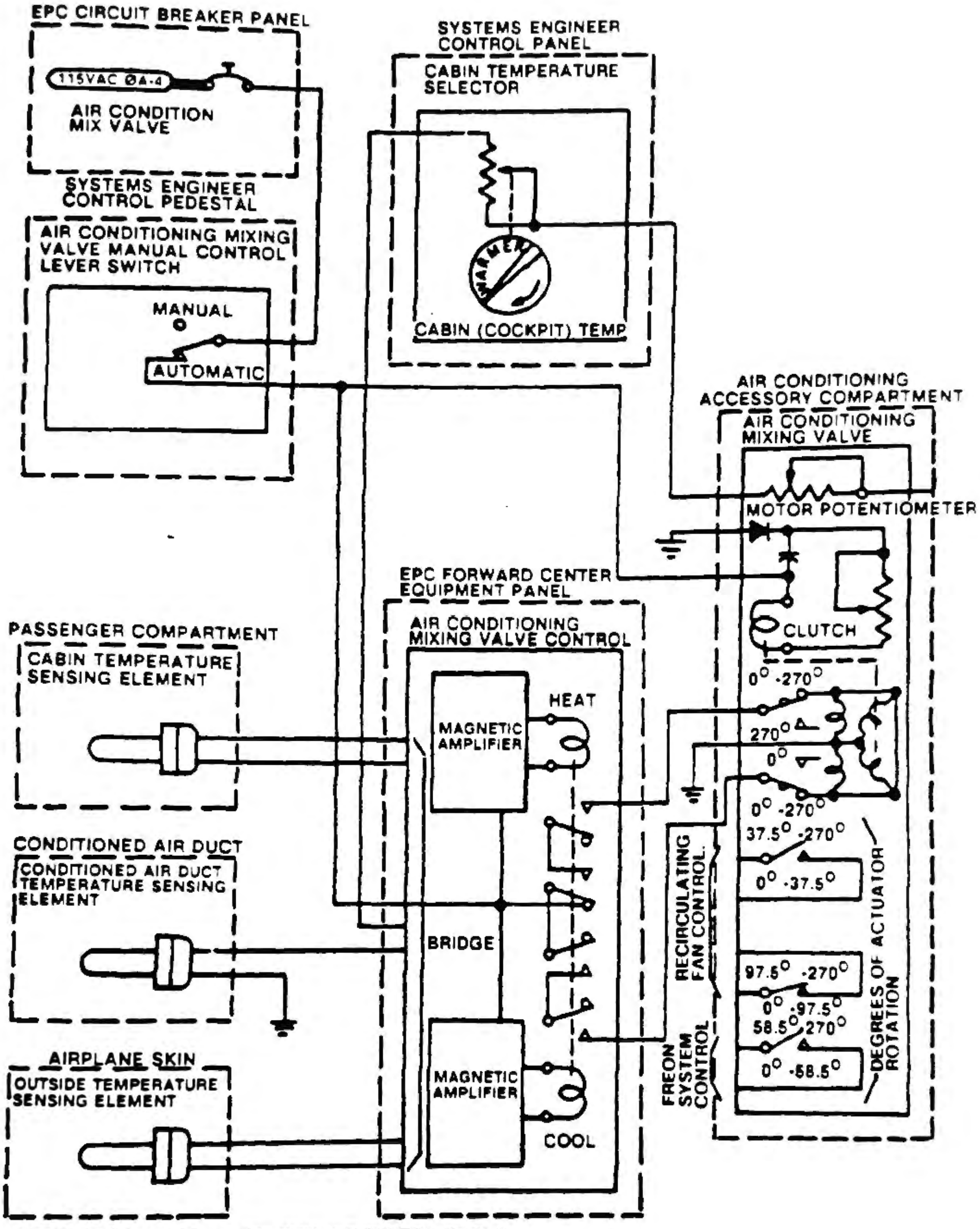
A. General (Figure 21-78)

(1) The cabin pressure control system is designed to provide the least cabin altitude change permissible within structural limitations of the fuselage, and to accomplish necessary cabin altitude changes at a comfortable rate. The desired cabin altitude can be set on the cabin pressure controller within the range of -1000 to +10,000 feet, and the cabin rate-of-change within the limits of 200 to 900 (±200) feet per minute. With the airplane higher than the selected cabin altitude, the control system attempts to achieve the selected cabin altitude at the rate-of-altitude change selected on the cabin pressure controller. Completion of the selected assignments is accomplished within a range of 0 to 8.77 psi cabin-to-atmosphere differential pressure regardless of airplane ascent or descent rates. The system also provides a means of correcting the controller altitude settings for variations in airport barometric pressure.

(2) The cabin pressure control system consists of the cabin pressure controller, cabin rate controller, cabin pressure controller amplifier, and cabin air outflow valve and actuator. The actuator is connected mechanically to the cabin air outflow valve linkage assembly and drives the valve as directed by the amplifier. Relays, circuit breakers, a cabin pressure automatic manual selector switch, and interconnecting wiring complete the system.

the higher temperature and adjusts the mixing valve of the right system to ensure that the cabin compartment selected temperature is not exceeded.

(3) The temperature control system is in automatic operation when the mixing valve manual control lever switch contacts are closed, apply 115 volts AC to the magnetic clutch of the mixing valve actuator and air conditioning mixing valve control unit (Figure 21-75). The switch is closed when the knob on the mixing valve manual control lever on the flight engineer's control pedestal is parallel with the lever quadrant. When the magnetic clutch is energized, the actuator motor is connected to the camshaft of the mixing valve, which in turn positions ports A, B, and C butterfly valves. The temperature selector in the flight compartment, combined with the temperature selector in the cabin compartment, conditioned air duct temperature sensing element, outside temperature sensing element, form a bridge circuit. These components are arranged in the bridge circuit so that the accumulated resistances balance each other. As long as balance is maintained, no current flows to the air conditioning mixing valve control unit amplifier. If the resistance of any one of these components is altered the bridge is unbalanced. The resulting current flow is directed to the appropriate magnetic amplifier where the current is amplified to a value which energizes the corresponding control relay. The contacts of each control relay are connected in the circuit, from the power source to the field coils of the mixing valve actuator motor through the mixing valve/center recirculating fan control relays which are controlled by the 0-129 degree position mix valve actuator switch preventing the mix valves from moving above the 129 degree position unless both mix valves are calling for back pressure heating. Direction of the actuator motor rotation depends upon which magnetic amplifier and associated control relay is energized, as determined by the polarity of the bridge signal. The wiper arm of the follow-up potentiometer is continually adjusted by movement of the actuator. The potentiometer is connected to form a portion of the bridge circuitry. When the changing resistance of the follow-up potentiometer attains a value that again balances the bridge, current flow ceases to the magnetic amplifier, the control relay deenergizes, and the power circuit to the actuator motor is opened. Any change in duct temperature or compartment temperature, or repositioning of a temperature selector, initiates signals which actuate the mixing valve.


EPC CIRCUIT BREAKER PANEL
115VAC ØA-4
AIR CONDITION MIX VALVE
SYSTEMS ENGINEER CONTROL PEDESTAL
AIR CONDITIONING MIXING VALVE MANUAL CONTROL LEVER SWITCH
MANUAL
AUTOMATIC
SYSTEMS ENGINEER CONTROL PANEL
CABIN TEMPERATURE SELECTOR
WARMER
CABIN (COCKPIT) TEMP
AIR CONDITIONING ACCESSORY COMPARTMENT
AIR CONDITIONING MIXING VALVE
MOTOR POTENTIOMETER
CLUTCH
0° -270°
270°
0°
0° -270°
37.5° -270°
0° -37.5°
97.5° -270°
0° -97.5°
58.5° -270°
0° -58.5°
DEGREES OF ACTUATOR ROTATION
RECIRCULATING FAN CONTROL
FREON SYSTEM CONTROL
EPC FORWARD CENTER EQUIPMENT PANEL
AIR CONDITIONING MIXING VALVE CONTROL
MAGNETIC AMPLIFIER
HEAT
BRIDGE
MAGNETIC AMPLIFIER
COOL
PASSENGER COMPARTMENT
CABIN TEMPERATURE SENSING ELEMENT
CONDITIONED AIR DUCT
CONDITIONED AIR DUCT TEMPERATURE SENSING ELEMENT
AIRPLANE SKIN
OUTSIDE TEMPERATURE SENSING ELEMENT

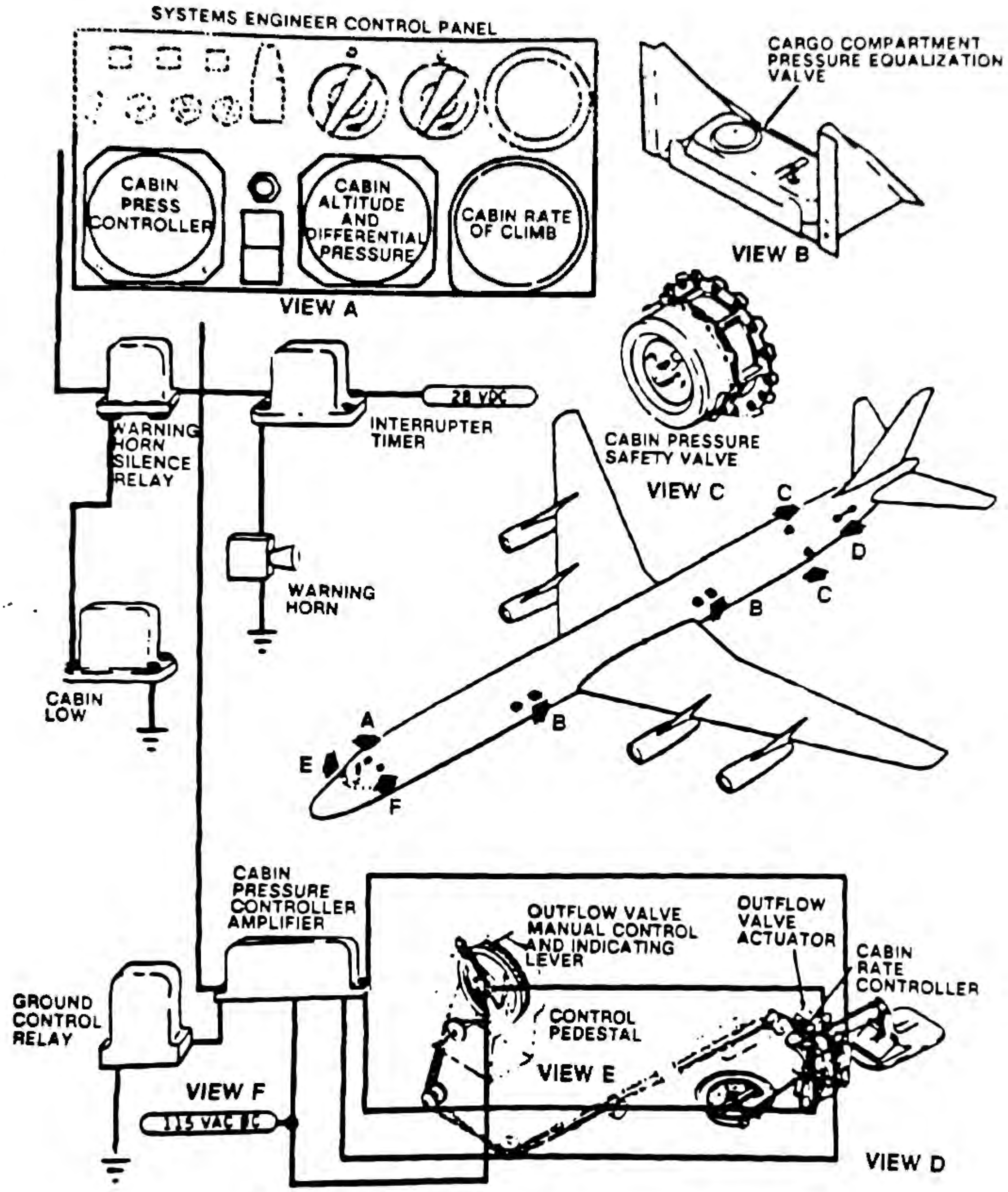
NOTE: PASSENGER COMPARTMENT SYSTEM SHOWN.
FLIGHT COMPARTMENT SIMILAR EXCEPT AS NOTED.

TEMPERATURE CONTROL ELECTRICAL SCHEMATIC

FTX80390

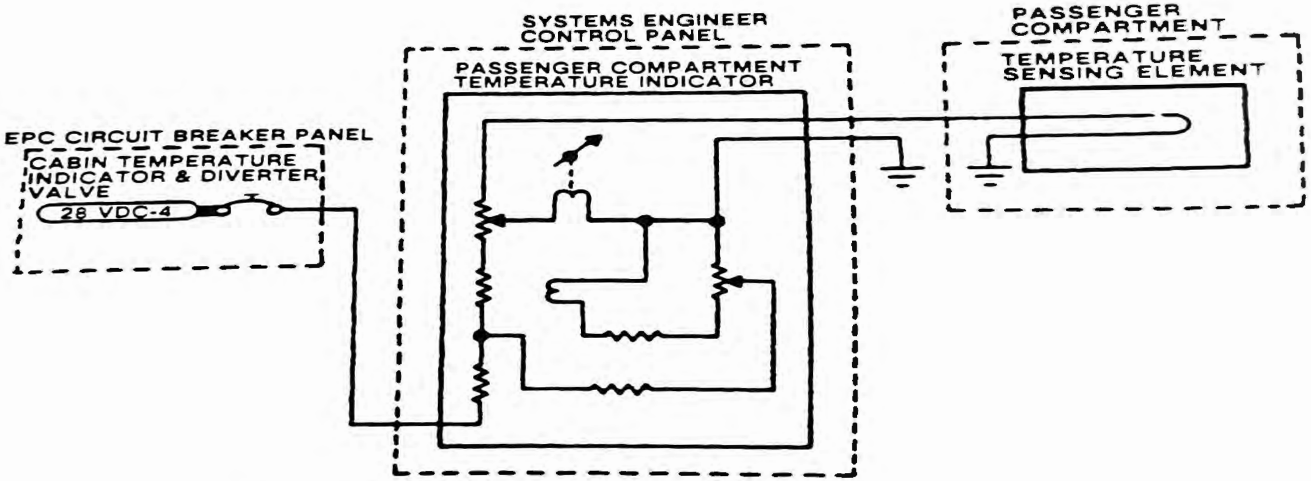
Figure 21-75

(4) During manual operation of the system, the mixing valve manual control lever switch contacts are open. The switch is in manual position (Figure 21-76) when the knob of the mixing valve manual control lever is extended and turned 90 degrees. No power is available to the magnetic clutch of the actuator motor, and the air conditioning mixing valve control unit is deenergized. Temperature control is maintained by positioning the manual control lever which rotates the mixing valve camshaft. Position of the valve is noted by the position of the lever on the control pedestal. Air temperature in the cabin compartment is monitored by the temperature indicator (Figure 21-77) in the flight compartment, and manual adjustment can be made to the temperature control system as required by the operator.


SYSTEMS ENGINEER CONTROL PANEL
CABIN PRESS CONTROLLER
CABIN ALTITUDE AND DIFFERENTIAL PRESSURE
CABIN RATE OF CLIMB
VIEW A
CARGO COMPARTMENT PRESSURE EQUALIZATION VALVE
VIEW B
WARNING HORN SILENCE RELAY
28 VDC
INTERRUPTER TIMER
CABIN PRESSURE SAFETY VALVE
VIEW C
WARNING HORN
CABIN LOW
A
B
C
D
E
F
CABIN PRESSURE CONTROLLER AMPLIFIER
OUTFLOW VALVE MANUAL CONTROL AND INDICATING LEVER
OUTFLOW VALVE ACTUATOR
CABIN RATE CONTROLLER
CONTROL PEDESTAL
VIEW E
GROUND CONTROL RELAY
VIEW F
115 VAC BC
VIEW D

CABIN PRESSURE CONTROL COMPONENTS FTX80345

Figure 21-78


SYSTEMS ENGINEER CONTROL PANEL
PASSENGER COMPARTMENT TEMPERATURE INDICATOR
PASSENGER COMPARTMENT
TEMPERATURE SENSING ELEMENT
EPC CIRCUIT BREAKER PANEL
CABIN TEMPERATURE INDICATOR & DIVERTER VALVE
28 VDC-4

TEMPERATURE INDICATION SCHEMATIC

FTX80341

Figure 21-77

15. Pressurization Control - Description and Operation

A. General

(1) Cabin pressurization is obtained by releasing conditioned air under pressure into the sealed areas of the fuselage, and limiting the rate at which air is exhausted to the atmosphere. The purpose of the pressurization control system is to keep the occupied areas of the airplane as near sea level pressure as possible, except as limited by the maximum allowable cabin pressure differential. The pressurized areas of the airplane can be maintained at sea level pressure up to a flight altitude of 23,000 feet. When the airplane is above 23,000 feet, the cabin altitude must be raised above sea level to prevent exceeding the cabin pressure differential limit. The cabin altitude is changed at a slow controlled rate for passenger comfort during climb and descent. The maximum cabin altitude change is to a pressure altitude of 6700 feet while the airplane is at 40,000 feet. This imposes a cabin-to-atmosphere pressure differential or 8.77 psi. The pressurization control section consists of the cabin pressure control system and cabin pressure indication.

(2) The major portion of the airplane fuselage is pressurized. The forward limit of the upper pressurized area is the bulkhead forward of the instrument panel. The forward limit of the lower pressurized area is the aft bulkhead of the nosewheel well. The aft limit of the pressurized area is the passenger compartment aft bulkhead. Pressurized bulkheads are built around the main landing gear well which is formed by the passenger compartment floor, the aft bulkhead of the forward cargo compartment, and the forward bulkhead of the aft cargo compartment.

(3) Four cabin compressors which are used for heating the conditioned air are also the pressure source for cabin pressurization. Pressure source is irrelevant to operation of the system, since differential pressures and flow across the air outflow valve determine cabin pressure control system requirements.

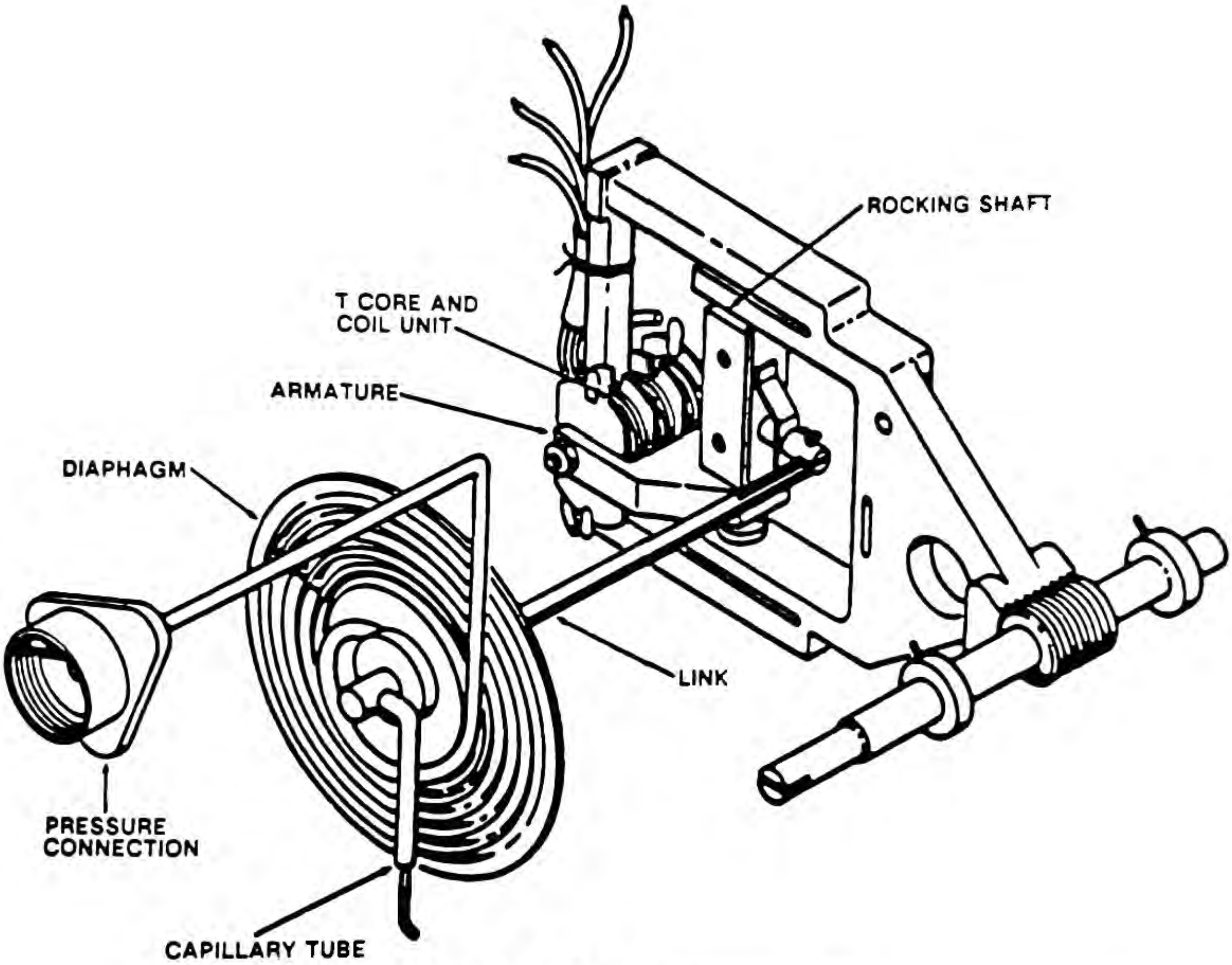
B. Description

(1) Cabin Pressure Control

(a) The cabin pressure control system components control ascent and descent rates within the pressurized areas of the fuselage while approaching the selected cabin altitude. This is done within structural limitations, regardless of ascent and descent rates of the airplane itself. Cabin pressure is normally maintained by opening and closing the cabin air outflow valve through automatic electronic control or by manual control. The cabin air outflow valve consists of two mechanically operated valves connected by a linkage arrangement. The linkage is automatically controlled by an electrically operated actuator, or manually controlled by the cabin air outflow valve manual control and indicating lever, which is connected by cables to the cabin air outflow valve linkage. The manual control and indicating lever, located on the systems engineer control pedestal in the flight compartment, also indicates the position of the cabin air outflow valve during automatic and manual operation.

(b) When the manual control and indicating lever is raised, power to the automatic control section is removed. The cabin air outflow valve can now be set to any desired position in the control quadrant. To maintain the selected position, the knob is turned 90 degrees and the lever lowered into the control quadrant teeth.

(c) Protection against excessive internal and external pressures to the fuselage is provided by the cabin pressure safety valves and the cargo compartment pressure equalization valves. The safety valves operate automatically to prevent an excessive cabin-to-atmosphere pressure differential. The equalization valves allow pressure between the passenger and lower cargo compartments to equalize automatically.



CABIN RATE CONTROLLER

FTX80348

Figure 21-81

(3) Pressure within the cabin is maintained by controlling the amount of air exhausted from the cabin through the cabin air outflow valve. This valve can be controlled automatically by the control system, or manually by adjustment of the manual control and indicating lever. The lever is connected mechanically by cables to the drum on the cabin air outflow valve linkage assembly, and serves as a valve position indicator during automatic operation.

(4) Cabin pressure safety valves are provided to relieve cabin pressure in the event the cabin-to-atmosphere differential pressure exceeds 8.81 (±0.10) psi. Negative pressure relief is provided by cabin doors moving inward.

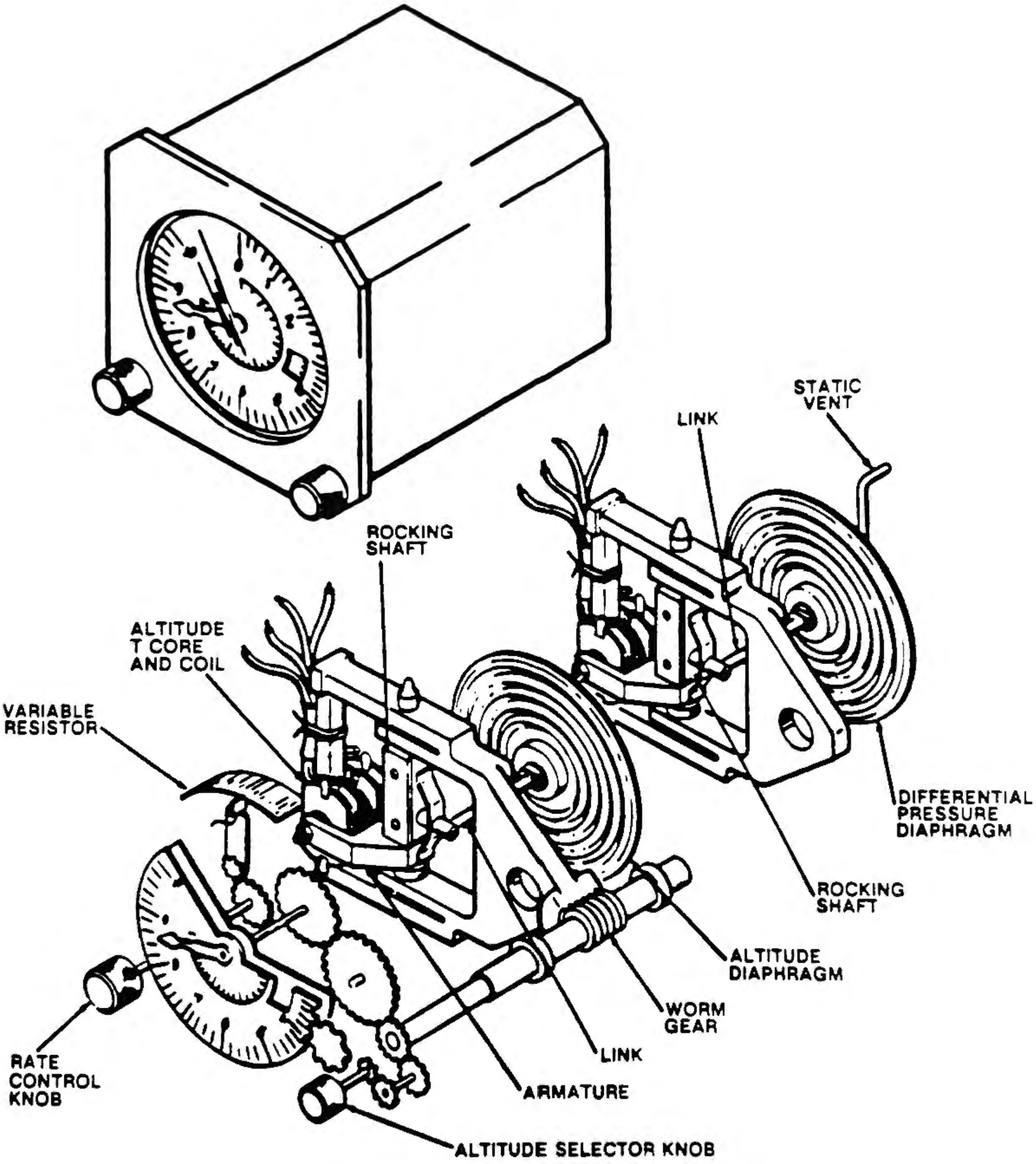
B. Component Description

(1) Cabin Pressure Controller (Figure 21-79)

(a) The cabin pressure controller is located on the systems engineer's control panel in the flight compartment. The controller accepts inputs from the altitude selector knob and rate control knob to establish electrical signals that change cabin pressure when a change is required. Housed in the pressure controller are an altitude monitor, a differential pressure monitor, a variable resistor, an altitude selector knob, a rate control knob, a dial and pointer to indicate the selected flight and cabin altitude, and a barometric scale to indicate the barometric setting of the controller.

(b) The altitude monitor includes a closed altitude diaphragm which is sensitive to cabin pressure, a T-core and coil unit, a rocking shaft, an armature, and a slotted link which connects the diaphragm to the rocking shaft. The differential pressure monitor includes a differential pressure diaphragm connected to a static vent, a differential T-core and coil unit, a rocking shaft, an armature, and a slotted link which connects the diaphragm to the rocking shaft. The differential pressure monitor is electrically connected in series with the altitude monitor, but the two monitors are mechanically independent of each other. A C-shaped iron armature is mounted in each rocking shaft, which is connected to the diaphragm by a link. An iron field structure within the armature carries four symmetrically wound coils connected in an inductive bridge (Figure 21-80).

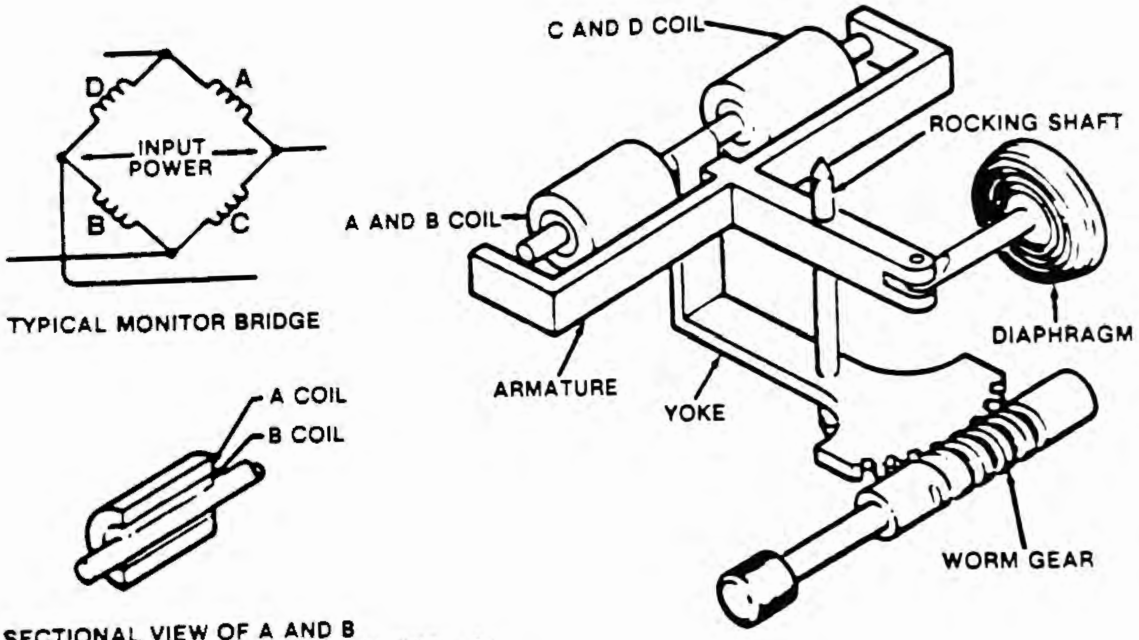
(c) The dial of the instrument contains two concentric scales, the outer scale indicating cabin altitude and the inner scale indicating maximum flight altitude. The cabin altitude scale is marked from -1000 feet to +10,000 feet. The flight altitude scale is marked from 23,000 feet to 50,000 feet. The variable resistor sets the bias of excitation voltage of the altitude monitor and determines the maximum and minimum rate-of-change to which the system will respond.



CABIN PRESSURE CONTROLLER

FTX80346

Figure 21-79



TYPICAL MONITOR BRIDGE

SECTIONAL VIEW OF A AND B
COIL STRUCTURE (C AND D COIL SIMILAR)

TYPICAL MONITOR BRIDGE SCHEMATIC

FTX80347

Figure 21-80

(d) The rate control knob is connected to the arm of the variable resistor and is used to set the desired rate of change of cabin altitude. A line inscribed on the rate control knob, and index marks adjacent to the knob, indicate the selected rate of cabin altitude change. In the minimum position, the approximate rate of change is 200 feet per minute or less; in the maximum position, the approximate rate of change is 700 feet per minute or greater. Stops prevent the knob from being turned beyond the maximum or minimum position.

(e) The altitude selector knob is used to set the controller to the maximum flight altitude at maximum cabin pressure differential. Because the scales are concentric, setting the flight altitude at maximum pressure differential also sets the corresponding cabin altitude. In the normal or retracted position, the knob actuates the pointer which indicates the cabin and maximum flight altitude. At the same time the pointer is set, the T-core and coil unit is positioned within the rocking shaft and armature unit. Stops are provided to prevent the pointer from being rotate beyond a position midway between the -1000- and 10,000-foot marking when the hand is being rotated in either direction. When the altitude selector knob is pulled out, the controller can be set to the desired barometric setting. The barometric pressure set on the controller is indicated on a stationary scale visible through a window in the dial. The barometric scale has a range of 28.1 to 31.0 inches of mercury or, if calibrated in millibars, a range of 950 to 1050 millibars. Stops are provided to prevent the dial from being rotated beyond the limits of the barometric scale.

(2) Cabin Rate Controller (Figure 21-81)

The cabin rate controller, mounted on the cabin air outflow valve drive bracket, is a rate-of-change of pressure monitor. The unit does not contain any flight adjustable controls and is provided with a blank cover plate. The controller automatically controls the rate-of-change of cabin pressure and contains a pressure-sensing diaphragm and monitor mechanism. The internal operating mechanism of the rate controller is composed of a diaphragm which is actuated by pressure changes within the cabin and rate controller. Pressure from the outflow valve is supplied in the diaphragm through an unrestricted tube and is vented into the rate controller case through a controlled leak capillary. When the air pressure varies because of changes in air velocity in the ing pressure in the reference pressure chamber and causing the outflow poppet to open. The pressure differential between reference pressure and cabin pressure across the outflow valve diaphragm causes the poppet to meter cabin air to atmosphere. This action overcomes the tension of the disc return spring and allows the discs to open. The opening and closing of the outflow poppet, because of changes in reference-to-cabin pressure differential, controls the cabin-to-atmosphere pressure differential. Pressure relief continues until cabin air pressure reduces to a pressure lower than that required to cause the differential diaphragm to unseat the metering valve.

(7) Cargo Compartment Pressure Equalization Valve

Two cargo compartment pressure equalization valves are installed in the ceiling of each cargo compartment and interconnect with the passenger compartment. The valves prevent differential pressure between the compartments exceeding 0.25 psi.

C. System Operation

(1) The cabin pressure control system attempts to maintain cabin pressure at the selected altitude and rate-of-altitude change, to enhance passenger comfort, and to avoid excessive stresses on airplane structures. The system is designed for automatic or manual control. Normal operation is automatic after selecting the desired cabin altitude and cabin rate-of-change on the cabin pressure controller. Airport barometric pressure corrected to sea level is also set on the cabin pressure controller prior to takeoff or landing. This setting is, in effect, a vernier control of cabin pressure to minimize pressure bumps during takeoff or landing. The altitude monitor in the cabin pressure controller originates signals which ultimately result in a change in cabin pressure when a change in cabin pressure is required. The differential pressure monitor prevents cabin-to-atmosphere differential pressure from exceeding 8.77 (±0.09) psi. The rate monitor in the cabin rate controller, combined with the variable resistor in the cabin pressure controller, establishes cabin pressure rate-of-change.

outflow valve, the pressure change in the case lags behind the pressure change in the diaphragm. The diaphragm reacts to this differential. A C-shaped iron armature is mounted on the rocking shaft, which is connected to the diaphragm by a link. An iron field structure within the armature carries four symmetrically wound coils connected in an inductive bridge (Figure 21-80). When the diaphragm expands, due to a change in pressure between the cabin outflow pressure and pressure inside the rate controller (surrounding the diaphragm), the resulting movement causes changes in the field within the armature. When the field changes, the inductance of one side increases while the opposite side decreases, resulting in an output voltage. When the output voltage exceeds the predetermined rate-of-change (set by the rate control knob on the cabin pressure controller), a signal is produced.

(3) Cabin Pressure Control Amplifier

(a) The cabin pressure control amplifier is located on the forward center equipment panel at the electrical power center. The amplifier contains suitable solid state electronic equipment to sum the inputs from the cabin pressure controller and cabin rate controller, amplify the result, and send a signal of 85 to 95 vac to drive the actuator in the proper direction and speed to attain smooth cabin pressure control.

(b) The amplifier consists of two stages of transistor preamplification and a full-wave magnetic amplifier output stage. The magnetic amplifier stage is a full-wave doubler type, using a center tapped output transformer to provide phase reversal of the output voltage. Bias windings provide an operating point for the magnetic amplifier output by using a small current. Bias current is supplied by a self-contained power supply which also provides DC voltage for the collector and emitter requirements of the preamplifier. The control windings of the magnetic amplifier are split into two coils for each reactor. The coils are interconnected in a manner to assure zero net magnetization in each core for conditions in which equal discriminator loop currents flow. Quadrature-components-of-error signals of 0 to 180 degrees produce appropriate magnetization changes in the magnetic amplifier cores to either cut off a pair of cores or drive the cores to saturation.

(c) The preamplifier is the conventional grounded emitter type using a transformer coupling to provide negative feedback. A constant current bias technique is used for ensuring temperature stability of the transistor collector circuit. The output of the preamplifier is coupled by a transformer to a full-wave phase discriminator network. This network converts the AC error signal into two DC loop currents and the magnitudes and polarities are dependent upon the amplitude and phase of the error signal. The phase and magnitude discrimination is made by comparing the amplifier error signal with the reference voltage. In the control windings, quiescent currents of the phase discriminator (which are always present due to the reference voltage) produce no effect until an error signal is introduced. The phase of the error signal determines which pair of cores are saturated and which pair are cut off.

(4) Cabin Air Outflow Valve

(a) The cabin air outflow valve is installed on the airplane centerline in the tail section skin and controls the outflow of air from the cabin, thereby controlling cabin pressure. The valve consists of a butterfly valve and a nozzle valve interconnected by a drive assembly. The drive assembly is connected to, and driven by, the cabin air outflow valve actuator, or is positioned manually in response to movement of the manual control and indicating lever in the flight compartment. In the closed position, both valves are flush with the fuselage skin. The nozzle valve incorporates a ramp-type gate which withdraws into the fuselage as the valve opens. The butterfly valve is located forward of the nozzle valve, and the portion of the valve that protrudes beyond the fuselage skin is parallel to the airstream in flight.

(b) Installed between the butterfly and nozzle valves is the drive assembly which consists of a main shaft, counter shafts, and connecting linkage. Movement of the main shaft is transmitted to the butterfly and nozzle valves through rods connected to bellcranks on the drive assembly. An electrically operated actuator and cable drums are installed on the main shaft, and, an electrically operated clutch within the actuator disengages the actuator drive from the main shaft. Cables are connected from the cable drum on the main shaft to a cable drum in the control pedestal. Mounted on the cable drum in the control pedestal is the manual control and indicating lever, which also serves as a valve position indicator during automatic and manual operations.

(c) On the ground, the drive assembly is driven fully clockwise by a ground sense signal; thus, the nozzle and butterfly valves are always fully open. This provides a low enough cabin pressure differential so that doors and flight compartment windows can be opened without discomfort to occupants when the air conditioning system is operating. It also limits the change in cabin pressure when the compressors are turned on. As the airplane ascends, automatic pressure control begins to close the butterfly valve while the nozzle valve remains wide open. The movement between butterfly and nozzle valve operation is accomplished by arrangement of the linkage and bellcranks on the drive assembly. Shortly after liftoff, the butterfly valve is fully closed. From this point on, cabin air outflow is controlled entirely by the nozzle valve. The double-valve arrangement permits accurate control of air outflow and permits handling of greater masses of air at low cabin pressure differential when both valves are open.

(d) By raising the manual control lever knob, a switch actuated by internal mechanism in the lever electrically disengages the clutch from the main shaft of the drive assembly. The lever, which is directly connected by cables to the main shaft of the drive assembly, may now be operated. After lifting the knob on the manual control lever to manual mode of operation, the knob is rotated 90 degrees to align pins on the base of the knob with teeth in the control quadrant. Releasing the knob in this position causes the pins to engage the teeth without returning to automatic mode of operation, and locks the valve in the selected position.

(5) Cabin Air Outflow Valve Actuator

(a) The cabin air outflow valve actuator is located on the cabin air outflow valve, and positions the cabin air outflow valve in response to signals from the cabin pressure control amplifier. The actuator consists of an AC induction motor, a solenoid-operated clutch, load-limit switches, and reduction gear train. The actuator is connected to the cabin air outflow valve linkage through the solenoid-controlled clutch and gear train.

(b) When the cabin pressure control system is in automatic mode, the clutch is energized to connect the motor, through the gear train, to the cabin air outflow valve linkage. As the motor rotates either clockwise or counterclockwise, the valve linkage opens or closes the butterfly and nozzle valves. If the valves become obstructed or the linkage jams, load-limit switches prevent damage to the actuator, valves, or linkage. The switches are set to shut off the actuator motor if torque on the output shaft exceeds 325 (±25) inch-pounds and, by using mechanical stops, limit the rotation of the output shaft to 150 (±2) degrees.

(c) When the cabin pressure control system is being manually controlled by the cabin air outflow valve manual control and indicating lever, the amplifier 115-VAC output that drives the actuator motor is disconnected. With the loss of power, the clutch is deenergized and the actuator shaft is allowed to run free with manual movement of the valve.

(6) Cabin Pressure Safety Valve (Figure 21-82)

(a) The cabin pressure safety valve consists of two principal parts: a base section and a head section. A diaphragm, secured between the two sections, forms a flexible airtight divider. The base section consists of an airflow valve diaphragm, a spring-loaded outflow poppet which rides on an outflow valve pilot and guide, two spring-loaded discs, and a base. The two discs and base mount flush with the airplane skin. The head section contains an atmosphere sensing port, a cabin air sensing port with a filter, a spring-loaded differential diaphragm, and a spring-loaded metering valve.

(b) The valve controls cabin-to-atmosphere pressure differential by releasing cabin air to atmosphere. Cabin air, introduced into the head section of the valve through the cabin air port, acts on one side of the differential diaphragm. Static atmospheric pressure, introduced into the head section of the valve through the atmosphere sensing connection, acts on the opposite side of the differential diaphragm. Pressure relief occurs when the metering valve unseats between 8.82 and 9.09 psi (8.81 and 9.18 psi on indicator) higher than atmospheric pressure. As the metering valve unseats, air flows from the reference pressure chamber through the metering valve and out to atmosphere, thereby reduc-

(d) Stop cabin compressors.

NOTE: **Stop compressors immediately after locking the lever in increase position to prevent cabin pressure from exceeding the relief valve opening pressure.**

(e) Place freon compressor switches in off position.

CAUTION: **ALLOW APPROXIMATELY 70 SECONDS AFTER STOPPING REFRIGERANT COMPRESSORS BEFORE DEENERGIZING ELECTRICAL BUSES TO ENSURE LUBRICATION OF REFRIGERANT COMPRESSOR UNTIL IT HAS STOPPED ROTATING.**

17. Cabin Pressure Indication - Description and Operation

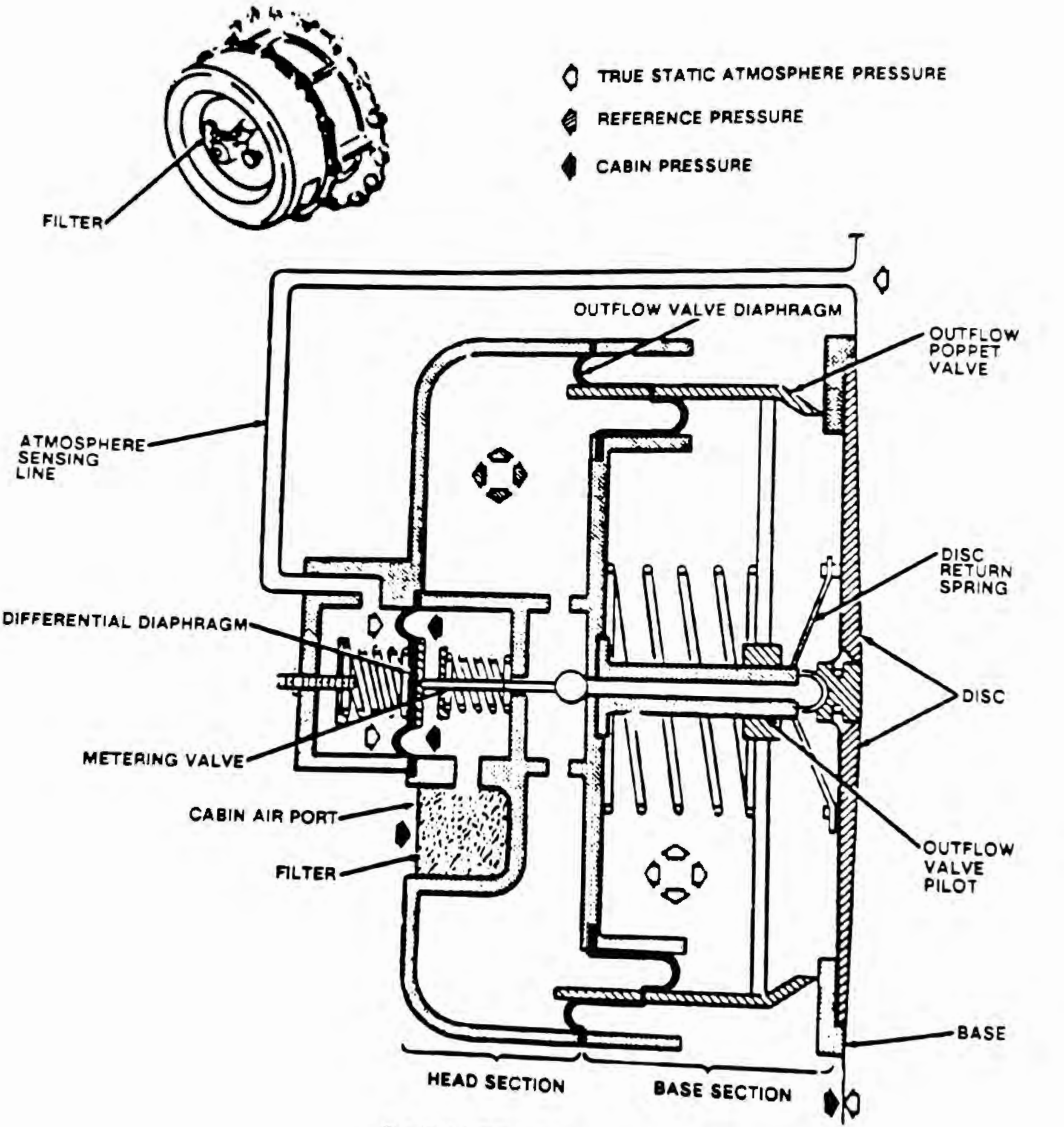
A. General

Operation of the cabin pressure control system is monitored by the cabin pressure indication components and a low-pressure warning system. Cabin pressure changes are monitored by the cabin altitude and differential pressure indicator and cabin rate-of-climb indicator. The cabin low-pressure warning system components function to warn the crew when cabin altitudes fall below predetermined levels. The low-pressure warning system consists of a takeoff and cabin low-pressure warning horn, horn interrupter time, cabin low-pressure switch, horn silence relay, and horn silence switch.

B. Component Description

(1) Cabin Altitude and Differential Pressure Indicator

The cabin altitude and differential pressure indicator is located on the systems engineer's control panel in the flight compartment. The indicator is a multiple-pointer instrument with two concentric scales. One scale is graduated in tenths of a psi of cabin-to-atmosphere differential pressure and the other scale is graduated in thousands of feet of cabin altitude. One pointer indicates cabin altitude in ranges from 0 to 50,000 feet, and the other pointer indicates cabin-to-atmosphere pressure differential in ranges from 0 to 10 psi. Included on the scale is a mark which represents the maximum differential



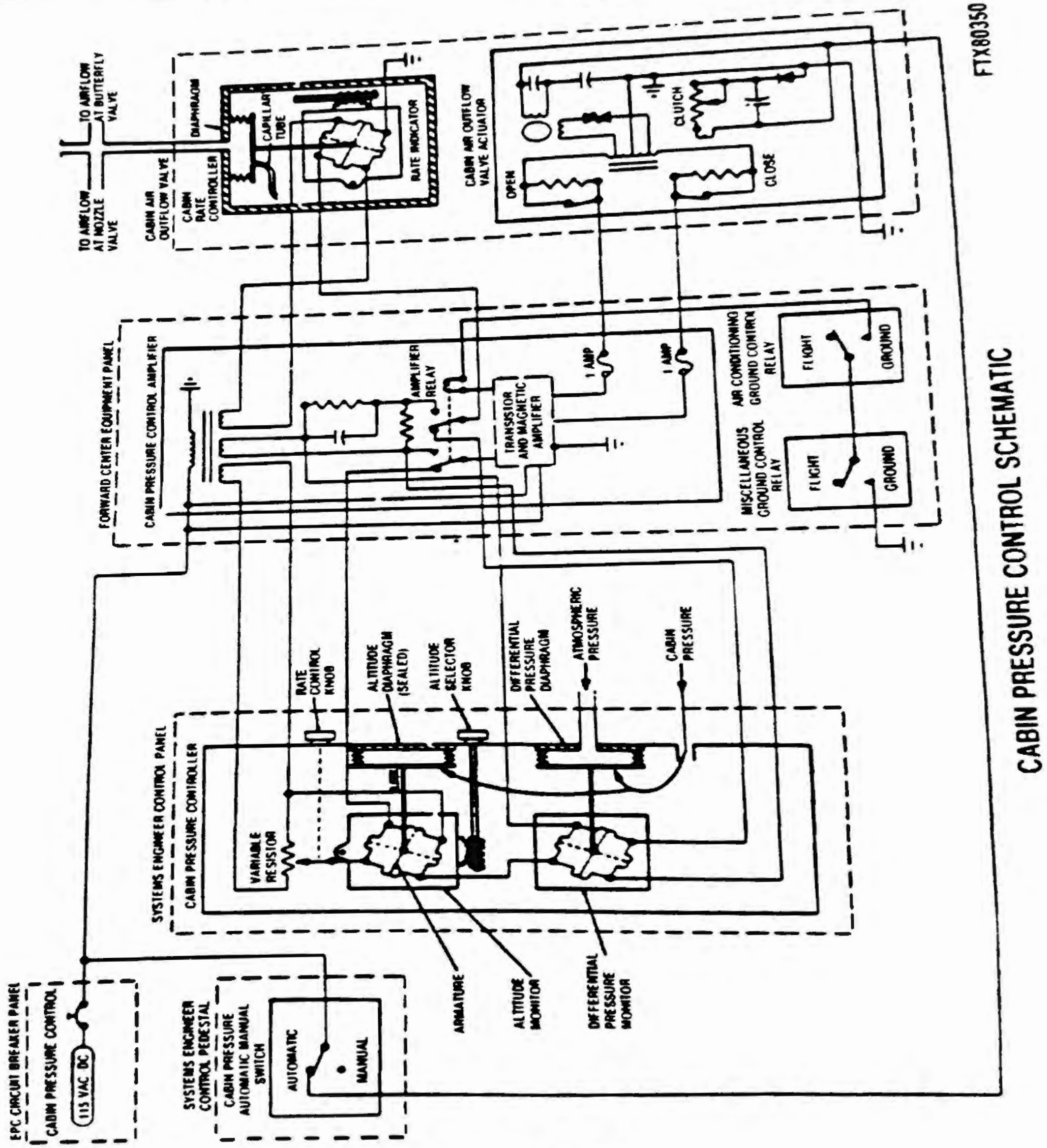
CABIN PRESSURE SAFETY VALVE

FTX80349

Figure 21-82

(2) With the cabin pressure automatic manual switch in automatic position and electrical power applied to the circuit breaker buses (Figure 21-83), the cabin air outflow valve actuator clutch solenoid is energized to engage the clutch with the cabin air outflow valve drive unit. When the airplane is on the ground, the cabin pressure control amplifier sends a valve open signal to the cabin air outflow valve actuator through contacts of the energize amplifier relay. The position of the armature within the altitude monitor can be varied mechanically by either the altitude selector knob or the diaphragm link. The diaphragm link is connected to the altitude diaphragm, which is sealed but externally sensitive to cabin pressure. Turning the cabin pressure controller altitude selector knob sets the pointer on the dial to the desired cabin altitude and also positions the altitude monitor unit with the worm gear. By pulling out the altitude selector knob, the airport barometric pressure can be set on the controller dial. This is a vernier setting which compensates for the position of the diaphragm link relative to the cabin pressure. The rate control knob positions the variable resistor to set the bias of excitation voltage of the altitude monitor. This setting determines the rate-of-change of altitude to which the system responds.

(3) On the ground, with all four cabin compressors operating, the cabin altitude descends below airport altitude (as set on the controller) with windows and doors closed. (Cabin altitude descends lower during takeoff because the effective discharge area of the outflow valve is reduced by the increasing velocity of the slipstream across the valves). At takeoff, ground control relay contacts close to deenergize the amplifier relay and cut off the valve open signal control of the valve position is now maintained by the altitude monitor, the differential pressure monitor, and the rate monitor, through the cabin pressure control amplifier.


CABIN PRESSURE CONTROL SCHEMATIC

FTX80350
EPC CIRCUIT BREAKER PANEL
CABIN PRESSURE CONTROL
115 VAC DC
SYSTEMS ENGINEER CONTROL PEDESTAL
CABIN PRESSURE AUTOMATIC MANUAL SWITCH
AUTOMATIC
MANUAL
SYSTEMS ENGINEER CONTROL PANEL
CABIN PRESSURE CONTROLLER
VARIABLE RESISTOR
RATE CONTROL KNOB
ALTITUDE DIAPHRAGM (SEALED)
ALTITUDE SELECTOR KNOB
DIFFERENTIAL PRESSURE DIAPHRAGM
ATMOSPHERIC PRESSURE
CABIN PRESSURE
ARMATURE
ALTITUDE MONITOR
DIFFERENTIAL PRESSURE MONITOR
FORWARD CENTER EQUIPMENT PANEL
CABIN PRESSURE CONTROL AMPLIFIER
AMPLIFIER RELAY
TRANSISTOR AND MAGNETIC AMPLIFIER
1 AMP
1 AMP
MISCELLANEOUS GROUND CONTROL RELAY
AIR CONDITIONING GROUND CONTROL RELAY
FLIGHT
GROUND
FLIGHT
GROUND
TO AIRFLOW AT NOZZLE VALVE
TO AIRFLOW AT BUTTERFLY VALVE
CABIN AIR OUTFLOW VALVE
CABIN RATE CONTROLLER
DIAPHRAGM
CAPILLARY TUBE
RATE INDICATOR
CABIN AIR OUTFLOW VALVE ACTUATOR
OPEN
CLOSE
CLUTCH

Figure 21-83

(4) The altitude selector knob is invariably set above airport altitude; therefore, the altitude monitor attempts to maintain a valve open position (depressurized condition) until airplane reaches the desired cabin pressure. The output voltage from the altitude monitor is 180 degrees out of phase with the output voltage of the rate monitor. The value of the fixed voltage applied at the altitude monitor is determined by the setting of the rate control knob on the cabin pressure controller. Therefore, the rate control knob setting selects the amount of error signal voltage delivered by the altitude monitor. The setting determines the amount of rate monitor signal voltage required to equal the voltage from the altitude monitor. As the airplane climbs with the valve open, the rate monitor notices the climb and begins to restrain the action of the altitude monitor by emitting and increasingly strong opposing signal. The relatively strong signal negates the altitude monitor signal, causing the valve to close so that the rate of climb of the cabin does not exceed the amount set on the cabin pressure controller. As the airplane continues to climb, the rate monitor allows the altitude monitor to attain the selected altitude, but only at the rate determined by the rate setting.

(5) During descent, similar commands and countercommands are made to maintain cabin differential pressures as required by the cabin pressure controller. Manual adjustments are made in flight to ensure that cabin pressure is maintained at a minimum and that cabin pressure equals airport altitude when the airplane lands. Ground relays, actuated during touchdown, energize the amplifier relay and a valve open signal is sent to the cabin air outflow valve actuator. Valve opening speed is controlled to depressurize the cabin (if the cabin is not already at airport altitude) at a rate of approximately 800 feet per minute.

(6) Manual operation of the cabin pressure control system, which completely overrides automatic operation, is accomplished by physically closing or opening the cabin air outflow valve with the manual control and indicating lever on the systems engineer's control pedestal. The manual control lever rack in the control pedestal allows the spring-loaded manual control knob to be locked in any position over the operating range. When the knob is raised, the cabin pressure automatic manual switch is set to deenergize the actuator clutch which disengages the actuator drive from the cabin air outflow valve. During manual operation in flight, cabin pressures and rate changes can be maintained by observing the cabin altitude and differential pressure

indicator and the cabin rate-of-climb indicator and by making the necessary adjustments with the manual control and indicating lever.

CAUTION: **GROUND OPERATING TIME OF A COMPRESSOR IS LIMITED BY HEAT CAPACITY OF LUBRICATING OIL UNLESS AUXILIARY COOLING AIR IS SUPPLIED. IF NONE IS SUPPLIED, CABIN COMPRESSOR OVERHEAT WARNING LIGHTS MUST BE CONTINUALLY MONITORED. IF A LIGHT COMES ON, STOP COMPRESSOR AND ALLOW SUFFICIENT TIME FOR OIL TO COOL BEFORE RESTARTING.**

NOTE: **Start additional compressors if necessary to obtain required differential pressure.**

(a) Place both freon compressor switches in normal position.

NOTE: **With low ambient temperatures, adequate cooling of the airplane is possible with one refrigeration system operating. If the air-conditioning mixing valve manual control and indicating levers are positioned toward the increase position (refrigeration system operating under light load), stop one of the refrigeration systems.**

(b) Pressurize cabin at a comfortable rate by slowly pushing cabin air out-flow valve manual control and indicating lever forward toward increase position.

CAUTION: **CABIN PRESSURE SAFETY VALVES SHOULD RELIEVE AT 8.81 (±.09) PSI DIFFERENTIAL PRESSURE. DO NOT ALLOW CABIN-TO-AMBIENT DIFFERENTIAL PRESSURE TO EXCEED 9.1 PSI IF SAFETY VALVES FAIL TO OPEN.**

(c) When desired differential pressure is achieved, place and lock cabin air outflow valve control and indicating lever to the full increase position.

pressure to which the cabin may be subjected in operation. Two other marks on the scale indicate the range of differential pressure control components. The indicator is connected into the airplane static system.

(2) Cabin Rate-of-Climb Indicator

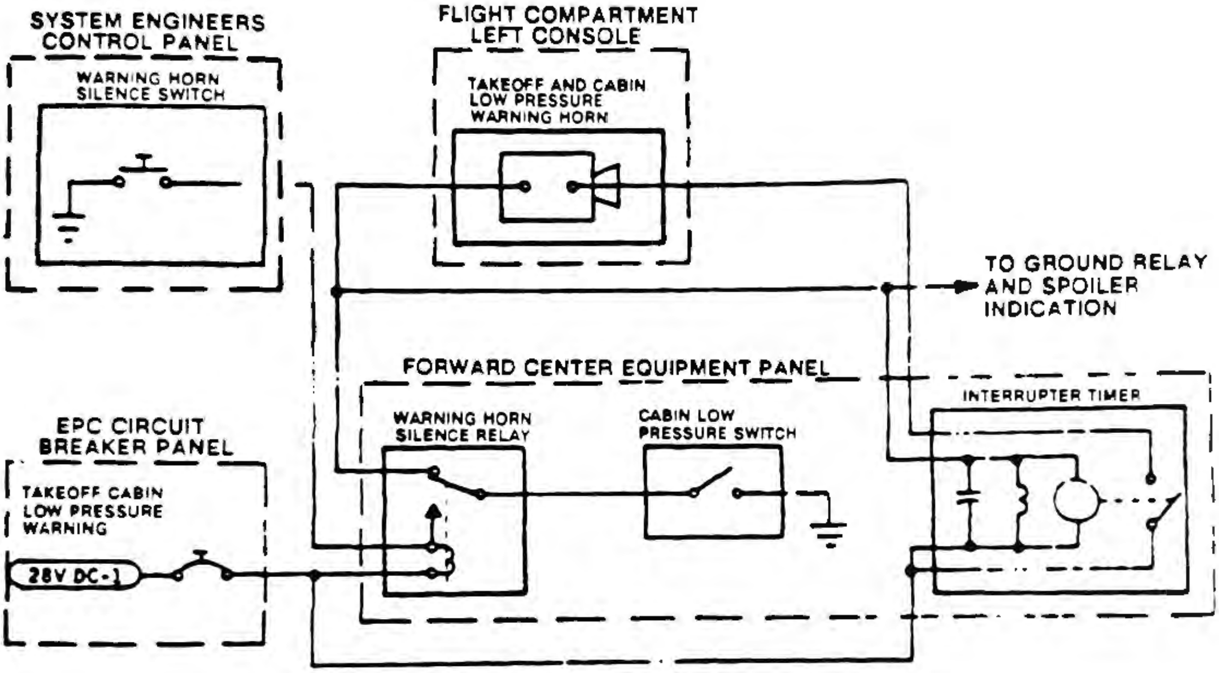
The cabin rate-of-climb indicator is located on the systems engineer control panel in the flight compartment. The indicator is a standard rate-of-climb instrument but is vented to cabin pressure. A single pointer in the dial indicates rates of climb and descent of cabin altitude in feet-per-minute, over ranges from 0 to +6000 and 0 to -6000.

(3) Cabin Low-Pressure Warning Components

The cabin low-pressure warning components are a takeoff and cabin pressure warning horn, a horn interrupter timer, a cabin low-pressure warning switch, a horn silence relay, and a horn silence switch. The horn is located in the captain's console, and the timer, switch, and relay are located on the forward center equipment panel in the electrical power center.

(4) System Operation

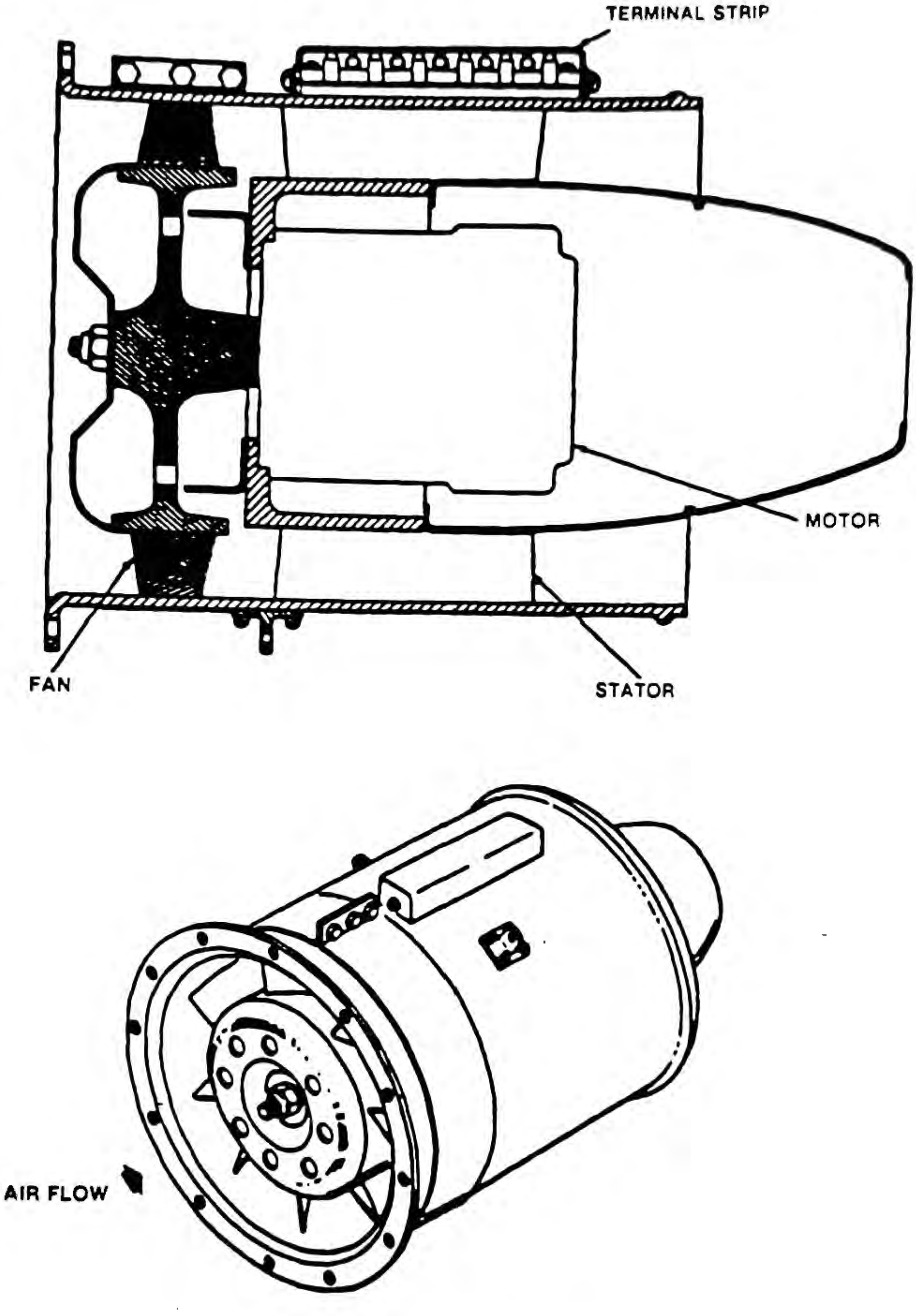
If airplane cabin altitude is increasing, the cabin low-pressure switch contacts close when the cabin altitude is between 9500 and 10,000 feet (Figure 21-84). The interrupter timer and horn are energized through the closed contacts of the warning horn silence relay from the 28-vdc circuit breaker. The timer sounds the horn intermittently as long as the low-pressure switch contacts are closed. When the cabin altitude decreases, the low-pressure switch contacts open when the cabin altitude reaches 8000 feet. The horn is silenced and the circuit is rearmed. The horn is silenced, if necessary, by pressing the warning horn silence switch on the systems engineer control panel. The warning horn silence relay is energized to open the circuit to the horn and timer.


SYSTEM ENGINEERS CONTROL PANEL
WARNING HORN SILENCE SWITCH
FLIGHT COMPARTMENT LEFT CONSOLE
TAKEOFF AND CABIN LOW PRESSURE WARNING HORN
TO GROUND RELAY AND SPOILER INDICATION
FORWARD CENTER EQUIPMENT PANEL
INTERRUPTER TIMER
WARNING HORN SILENCE RELAY
CABIN LOW PRESSURE SWITCH
EPC CIRCUIT BREAKER PANEL
TAKEOFF CABIN LOW PRESSURE WARNING
28V DC-1

CABIN PRESSURE WARNING CIRCUIT

FTX80351

Figure 21-84



RECIRCULATING FAN – DESCRIPTION

FTX80642

Figure 21-2

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1. Pressurization Control - Description and Operation

A. Cabin Air Outflow Valve

(1) The cabin air outflow valve is installed on the airplane centerline in the tail section skin and controls the outflow of air from the cabin, thereby controlling cabin pressure. The valve consists of a butterfly valve and a nozzle valve interconnected by a drive assembly. The drive assembly is connected to, and driven by, the cabin air outflow valve actuator, or is positioned manually in response to movement of the manual control and indicating lever in the flight compartment. In the closed position, both valves are flush with the fuselage skin. The nozzle valve incorporates a ramp-type gate which withdraws into the fuselage as the valve opens. The butterfly valve is located forward of the nozzle valve, and the portion of the valve that protrudes beyond the fuselage skin is parallel to the airstream in flight.

(2) Installed between the butterfly and nozzle valves is the drive assembly which consists of a main shaft, counter shafts, and connecting linkage. Movement of the main shaft is transmitted to the butterfly and nozzle valves through rods connected to bellcranks on the drive assembly. An electrically operated actuator and cable drum are installed on the main shaft, and an electrically operated clutch within the actuator disengages the actuator drive from the main shaft. Cables are connected from the cable drum on the main shaft to a cable drum in the control pedestal. Mounted on the cable drum in the control pedestal is the manual control and indicating lever, which also serves as a valve position indicator during automatic and manual operations.

(3) On the ground, the actuator drives the valve open by a ground sense signal through the ground control relays. In this position, the nozzle valve is full open and the butterfly valve is limited to 35 (±5) degrees of travel from the full closed position by a mechanical stop and limit switch. A low enough cabin pressure differential is maintained so that doors and flight compartment windows can be opened without discomfort to the occupants when the air conditioning systems are operating. It also limits the change in cabin pressure when the compressors are turned on. As the airplane ascends, automatic pressure control begins to close the butterfly valve while the nozzle valve remains wide open.

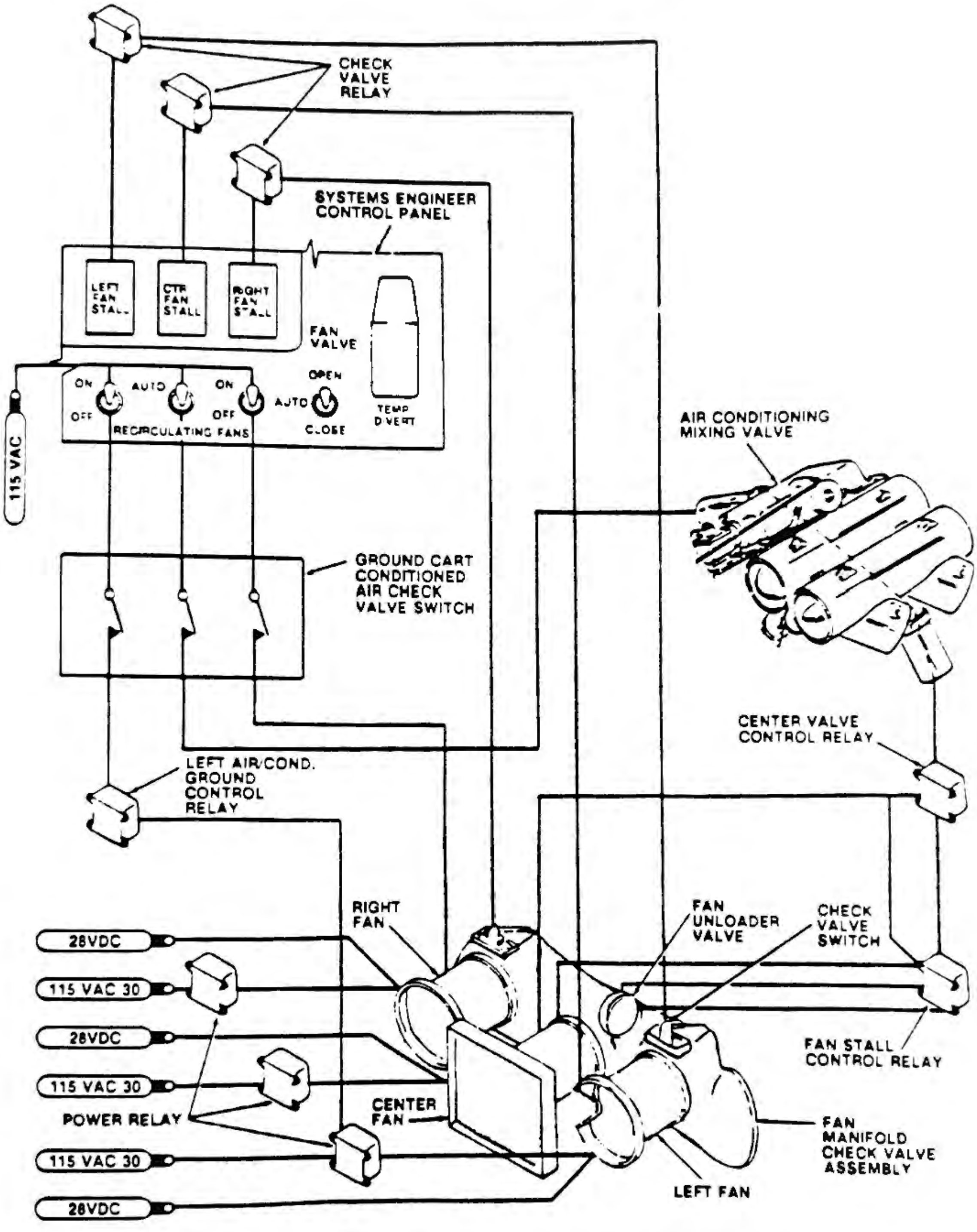
The movement between butterfly and nozzle valve operation is accomplished by arrangement of the linkage and bellcranks on the drive assembly. Shortly after liftoff, the butterfly valve is fully closed. From this point on, cabin air outflow is controlled entirely by the nozzle valve. The double-valve arrangement permits accurate control of air outflow and permits handling of greater masses of air at low cabin pressure differential when both valves are open.

2. Cabin Air Recirculation Fan Control - Description and Operation

A. General (See Figure 21-1)

(1) Three recirculating fans provide air recirculation from the air-conditioning accessory compartments (pressurized area), through the fan manifold, and across the refrigerant evaporator to the distribution system. The right and left fans are normally inoperative in flight when all four cabin compressors are operating, but the right fan may be turned on to give added circulation if only two cabin compressors are operating. The fans are manually controlled from the systems engineer control panel. When the airplane electrical buses are energized and the center fan switch is in automatic position, the center fan operates continuously except when the air-conditioning mixing valves go into back pressure heating. To obtain maximum cooling on the ground, the cabin compressors are turned off and the right and left recirculating fans are turned on.

(2) A check valve is installed downstream form each recirculating fan to prevent backflow of air from the manifold through the inoperative fans. Each check valve is equipped with a switch which is actuated by the flapper assembly. To reduce system back pressure during fan starting, a recirculating fan unloader valve is installed in the fan manifold. Stall warning indicating lights on the systems engineer control panel come on when the fans are in a stalled or inoperative condition when the fan power circuits are energized. The ground-conditioned air check valve switch prevents operation from any of the three fans if conditioned air is being delivered from a ground source.



CABIN AIR RECIRCULATION FAN ELECTRICAL SYSTEM

FTX80641

Figure 21-1

B. Component Description

(1) Recirculating Fan (See Figure 21-2)

Three recirculating fans are mounted on the recirculating fan manifold in the air-conditioning accessory compartment. The fans provide the required circulation of air from the pressurized air-conditioning accessory compartment, through the evaporators of the refrigeration system, the air-conditioning mixing valves, and the air distribution system. Each recirculating fan contains a 115 vac, 3-phase electric motor, an overload and heat protection circuit and a manual reset circuit. Each fan is equipped with bellmouth inlets. The center fan is equipped with a filter.

(2) Recirculating Fan Unloader Valve

The recirculating fan unloader valve is installed in the recirculating fan manifold in the air-conditioning accessory compartment, and is provided to reduce system back pressure during fan starting. The valve consists of a butterfly valve and actuator. The actuator contains a 115-volt, single phase electric motor, reduction gear, and limit switches to limit actuator travel. A mechanical indicator is provided to verify full closed position.

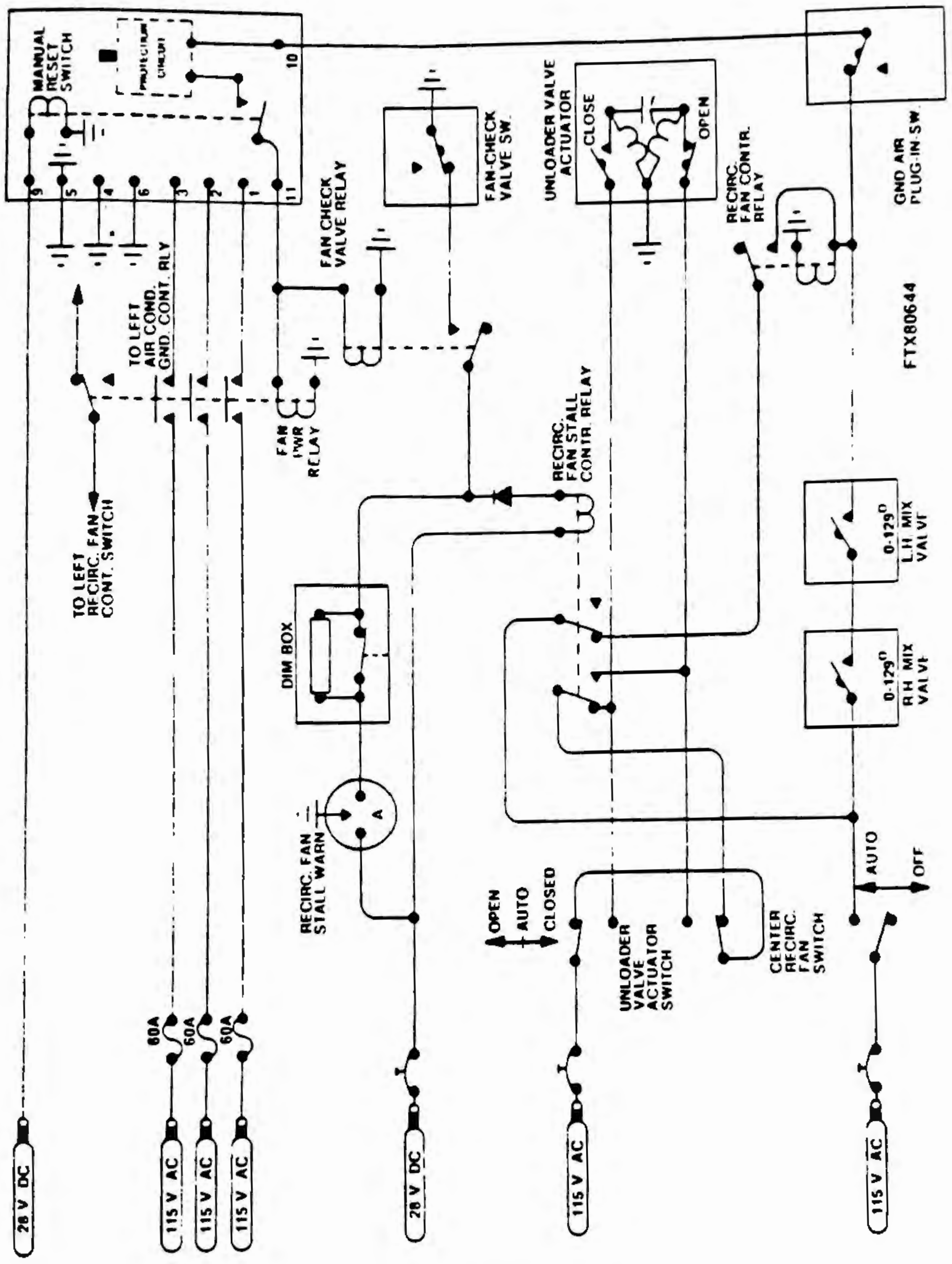
(3) Recirculating Fan Check Valve and Switch

Three recirculating fan check valves and corresponding switches are installed in the recirculating fan manifold. The manifold, installed between the inlet ports of the right and left refrigerant headers, contains three inlet ports for mounting the recirculating fans and one outlet port for mounting the unloader valve. The manifold is strengthened with channel stiffeners at the fan inlet port areas. The three flapper assemblies which form the check valves are mounted so that the fan inlet ports are closed when the corresponding fan is not operating. Contacts of the circulating fan check valve switch, which is installed adjacent to each flapper, and open when the flapper is completely open. The switch is connected into the control circuit used for controlling fan starting, unloader valve actuation, and stall warning.

C. System Operations (See Figure 21-4)

(1) Normal flow of air to the passenger and flight compartment from the air-conditioning system is through the conditioned air and cold air distribution ducts. Exhaust air from the passenger compartment flows through grills below the sidewall panels, through openings in the floor structure, to the air-conditioning utility tunnels. With the recirculating fans operating, flow is from the utility tunnels into the air-conditioning accessory compartment where the recirculating fans are located. The recirculating fans draw air into the recirculating fan manifold for recirculation through the air-conditioning system. A flapper installation adjacent to each fan forms a check valve for manifold air when the corresponding fan is inoperative. Each flapper manually actuates a check valve switch when the fan is operating at normal speed.

(2) The left, right, and center recirculating fan internal circuits are identical, but the logic of operation of each fan is different. The fan protection circuits (see Figure 21-3) are energized when 28 vdc is applied to the airplane electrical buses, and the protection relays are energized to close the relay contacts. The double-coil latching relay in the fan is also energized to close the contacts. When ground supplied conditioned air is not being delivered, the three sets of contacts in the ground conditioned air check valve switch are closed. (The ground conditioned air check valve switch opens to deenergize the three fan circuits if ground conditioned air is being delivered into the distribution system at 10 ±2 inches of water pressure.) Closing the right recirculating fan switch contacts, energizes the right fan check valve relay and right fan power relay with 115 VAC, through closed contacts of the ground conditioned air check valve switch and contacts of the fan internal relays. The right fan power relay contacts close to energize the fan motor circuits from the generator bus bay, and the fan starts. Contacts of the right recirculating fan check valve switch remain closed until air from the recirculating fan opens the flapper sufficiently to actuate the switch. Since contacts A1 and A2 of the energized right fan check valve relay are closed, the recirculating fan stall control relay coil is energized from the recirculating fan stall warning circuit breaker. When the recirculating fan stall control relay is closed, power is supplied through contacts B1 and B2 to actuate the recirculating fan unloader valve to the open position and relieve pressure in the circulating fan manifold. As the fan comes up to speed,



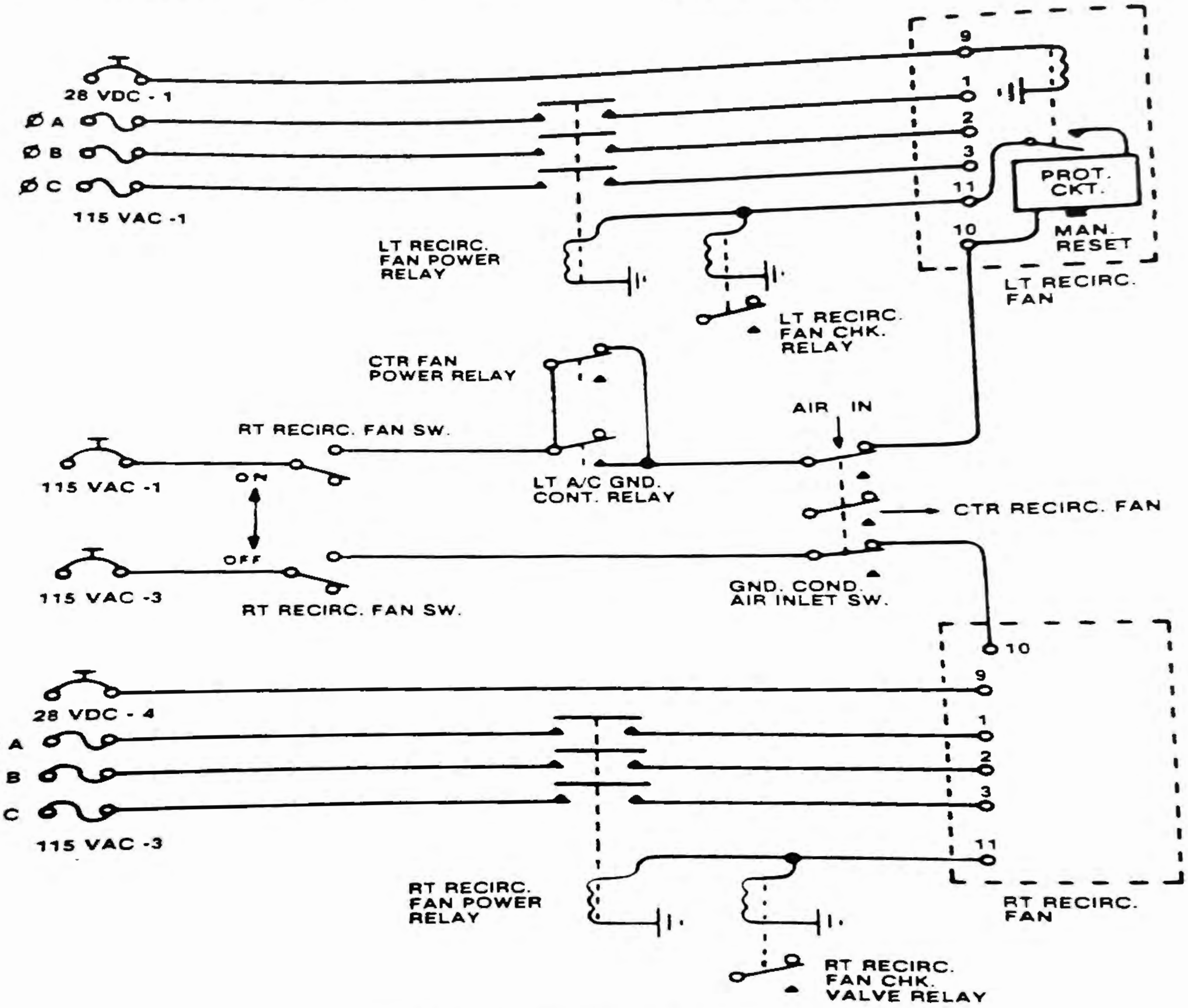
CENTER RECIRCULATION FAN CONTROL

FTX80644

Figure 21-5

contacts of the right recirculating fan check valve switch open, the recirculating fan stall control relay is deenergized, and the recirculating fan unloader valve is driven to the closed position.

(3) The circuit for the left fan is similar to the right fan except that 115 VAC power is routed through the left air-conditioning ground relay before being applied to the fan power relay. A circuit, parallel with the left air-conditioning ground relay contacts B1 and B2, is directed through contacts D1 and D2 of the center fan power relay. Contacts D1 and D2 are closed when the center fan power relay is deenergized, allowing the left fan to be operated only when the center fan is not operating. The left air- conditioning ground relay contacts, however, are closed when the airplane is on the ground, therefore the left fan may be operated on the ground when the center fan is operating. In flight, the left fan can only be operated when the center fan is not operating.



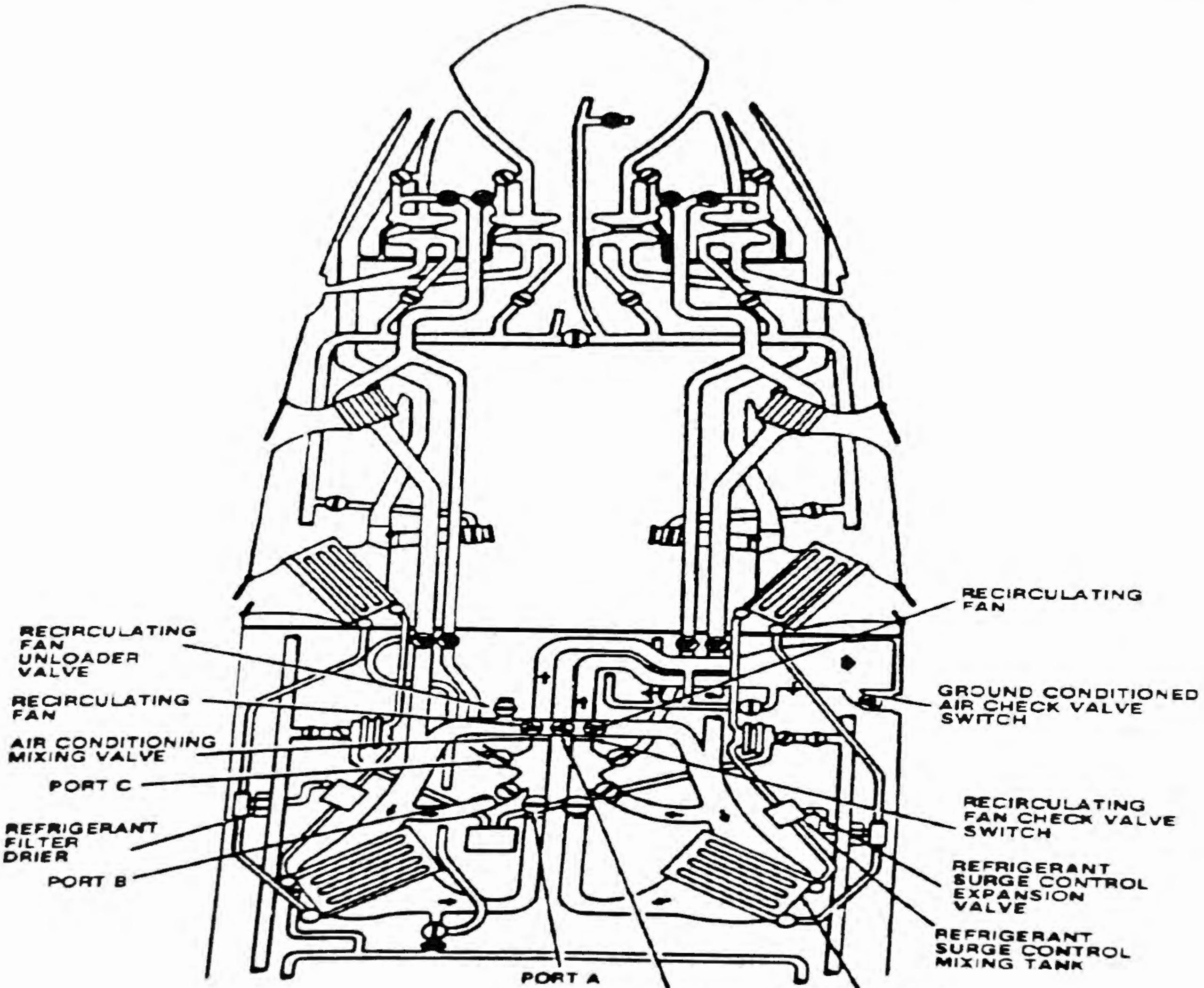
LT & RT RECIRC FAN CONTROL

FTX8644A

Figure 21-3

(4) The center recirculating fan switch can be placed in off or automatic position. In automatic position, the fan operates continuously on the ground and in flight, except when either air- conditioning mixing valve goes into back pressure heating (that is, the air-conditioning mixing valve camshaft is between approximately 129 and 270 degrees of rotation). When the center recirculating fan control circuit is energized, and the right and left air-conditioning mixing valves are between 0 and 129 degrees of rotation, the recirculating fan control center relay coil is energized. Closed contacts A1 and A2 of this relay, and contacts A2 and A3 of the deenergized recirculating fan stall control relay, form a latching circuit for the recirculating fan control center relay. If either air-conditioning mixing valve camshaft rotates beyond 129 degrees of rotation, the power circuit to the center recirculating fan is maintained through the latching circuit. As the port B butterfly valve is the air-conditioning mixing valves continues to close, a back pressure is built up in the fan manifold, causing the center recirculating fan check valve switch to close. The recirculating fan stall control relay is energized, and the control circuit to the center fan and to the recirculating fan control center relay is opened. The fan power circuit cannot be energized again until both air-conditioning mixing valves are between 0 and 129 degrees of camshaft rotation and the camshaft switches are closed. When either temperature control mix valve, moving singly reaches the 129 degree position from (0 degree) an integral switch removes power from a relay. The relay opens a circuit to the center fan control relay and interrupts power to the respective mix valve actuator. When both mix valves reach 129 degrees both relays are deactivated and the power input path to both mix valves is restored allowing further possible movement beyond 129 degrees of both mix valves. The center fan function is determined by position of the center recirculation fan stall control relay until both mix valves resume a position below 129 degrees.

(5) The recirculating fan unloader valve can be opened and closed manually, as well as automatically, during fan starting. When the recirculating fan unloader valve switch is in closed position, contacts A1 and A2, and B1 and B2 are closed to supply power directly to actuate the close circuit of the valve. When the recirculating fan unloader valve switch is in open position, contacts A2 and A3, and B2 and B3 are closed to supply power directly to actuate the open circuit of the valve.


RECIRCULATING FAN
RECIRCULATING FAN UNLOADER VALVE
RECIRCULATING FAN
GROUND CONDITIONED AIR CHECK VALVE SWITCH
AIR CONDITIONING MIXING VALVE
PORT C
RECIRCULATING FAN CHECK VALVE SWITCH
REFRIGERANT FILTER DRIER
REFRIGERANT SURGE CONTROL EXPANSION VALVE
PORT B
REFRIGERANT SURGE CONTROL MIXING TANK
PORT A
RECIRCULATING FAN
REFRIGERANT EVAPORATOR

RECIRCULATING FAN AIRFLOW

FTX80643

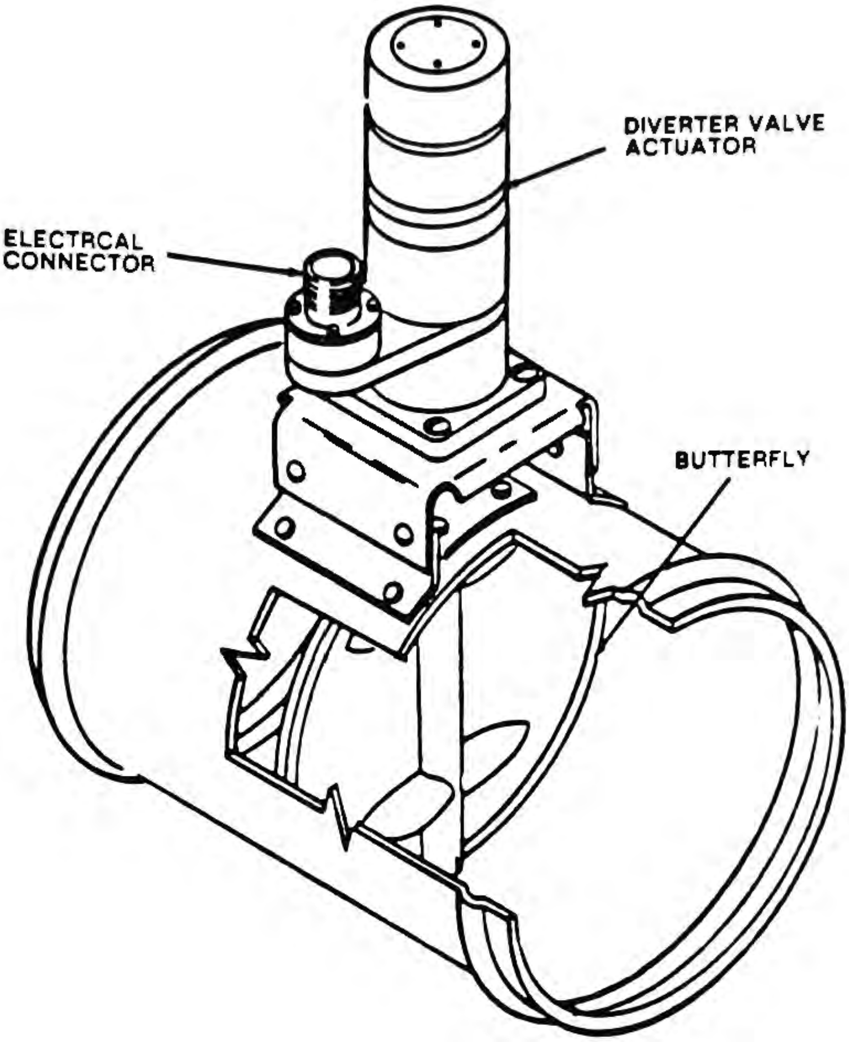
Figure 21-4

(6) A stall warning indicating light is provided for each recirculating fan. When the fan control circuit is energized and the corresponding recirculating fan check valve switch is closed (fan not operating or in a stalled condition), the stall warning indicating light comes on. During normal fan starting procedures, while the unloader valve is open allowing the fan to reach operating speed, the stall warning light comes on momentarily.

3. Distribution - Description and Operation

(1) Temperature Diverter Valve (See Figure 21-6)

A temperature diverter valve is installed between the flight compartment conditioned air ducts and the main passenger compartment distribution duct in the air conditioning accessory compartment. The butterfly-type valve is driven by an actuator, which consists of a 28-vdc motor, reduction gear, and limit switches. The temperature diverter valve 2-position switch (see Figure 21-1) is located on the system engineer's control panel in the flight compartment, and is guarded in the closed position. Normally, flight compartment conditioned air is directed from the lower section of the pant leg duct. If the flight compartment air conditioning system is inoperative, opening the diverter valve allows passenger compartment system airflow to the diverted to the flight compartment conditioned air ducts.



TEMPERATURE DIVERTER VALVE – DESCRIPTION

FTX80645

Figure 21-6

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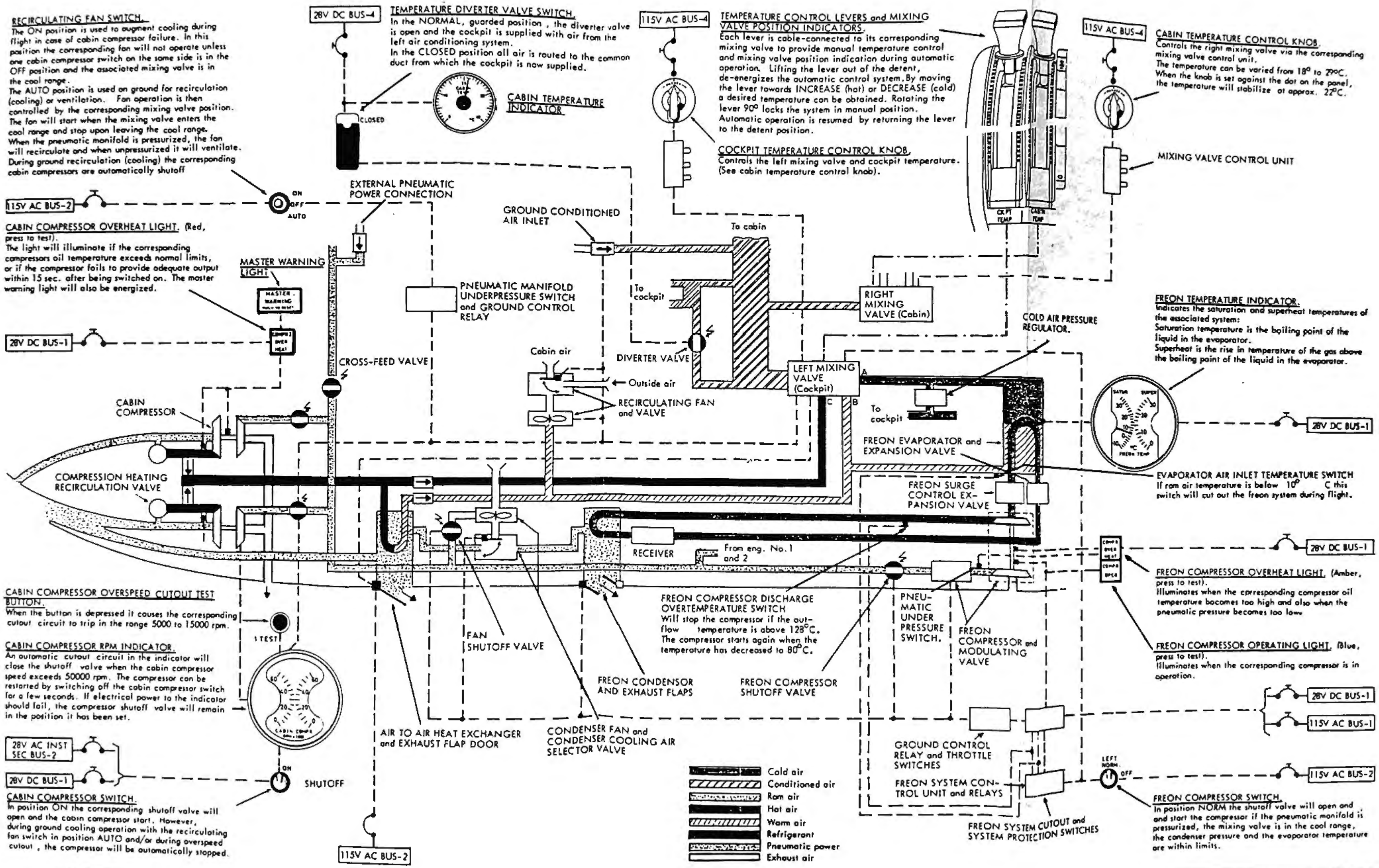
AIR CONDITIONING
Description



28V DC BUS-4
CLOSED
CABIN TEMPERATURE INDICATOR
115V AC BUS-4
115V AC BUS-4
MIXING VALVE CONTROL UNIT
CKPT TEMP
CABIN TEMP
115V AC BUS-2
ON
OFF
AUTO
EXTERNAL PNEUMATIC POWER CONNECTION
GROUND CONDITIONED AIR INLET
To cabin
MASTER WARNING LIGHT
MASTER WARNING
28V DC BUS-1
COMPR OVER HEAT
PNEUMATIC MANIFOLD UNDERPRESSURE SWITCH and GROUND CONTROL RELAY
To cockpit
RIGHT MIXING VALVE (Cabin)
COLD AIR PRESSURE REGULATOR.
Cabin air
DIVERTER VALVE
CROSS-FEED VALVE
Outside air
LEFT MIXING VALVE (Cockpit)
A
B
C
To cockpit
CABIN COMPRESSOR
RECIRCULATING FAN and VALVE
FREON EVAPORATOR and EXPANSION VALVE
28V DC BUS-1
COMPRESSION HEATING RECIRCULATION VALVE
FREON SURGE CONTROL EXPANSION VALVE
RECEIVER
From eng. No. 1 and 2
28V DC BUS-1
COMPR OVER HEAT
COMPR OPER
1 TEST
FAN SHUTOFF VALVE
PNEUMATIC UNDER PRESSURE SWITCH.
FREON COMPRESSOR and MODULATING VALVE
FREON CONDENSOR AND EXHAUST FLAPS
FREON COMPRESSOR SHUTOFF VALVE
28V DC BUS-1
115V AC BUS-1
CABIN COMPR
28V AC INST SEC BUS-2
28V DC BUS-1
ON
SHUTOFF
AIR TO AIR HEAT EXCHANGER and EXHAUST FLAP DOOR
CONDENSER FAN and CONDENSER COOLING AIR SELECTOR VALVE
GROUND CONTROL RELAY and THROTTLE SWITCHES
FREON SYSTEM CONTROL UNIT and RELAYS
FREON SYSTEM CUTOUT and SYSTEM PROTECTION SWITCHES
LEFT
NORM
OFF
115V AC BUS-2
115V AC BUS-2
SATUR
SUPER
FREON TEMP
Cold air
Conditioned air
Ram air
Hot air
Warm air
Refrigerant
Pneumatic power
Exhaust air

RECIRCULATING FAN SWITCH.
The ON position is used to augment cooling during flight in case of cabin compressor failure. In this position the corresponding fan will not operate unless one cabin compressor switch on the same side is in the OFF position and the associated mixing valve is in the cool range.
The AUTO position is used on ground for recirculation (cooling) or ventilation. Fan operation is then controlled by the corresponding mixing valve position. The fan will start when the mixing valve enters the cool range and stop upon leaving the cool range. When the pneumatic manifold is pressurized, the fan will recirculate and when unpressurized it will ventilate. During ground recirculation (cooling) the corresponding cabin compressors are automatically shutoff

CABIN COMPRESSOR OVERHEAT LIGHT. (Red, press to test).
The light will illuminate if the corresponding compressors oil temperature exceeds normal limits, or if the compressor fails to provide adequate output within 15 sec. after being switched on. The master warning light will also be energized.

TEMPERATURE DIVERTER VALVE SWITCH.
In the NORMAL, guarded position, the diverter valve is open and the cockpit is supplied with air from the left air conditioning system.
In the CLOSED position all air is routed to the common duct from which the cockpit is now supplied.

TEMPERATURE CONTROL LEVERS and MIXING VALVE POSITION INDICATORS.
Each lever is cable-connected to its corresponding mixing valve to provide manual temperature control and mixing valve position indication during automatic operation. Lifting the lever out of the detent, de-energizes the automatic control system. By moving the lever towards INCREASE (hot) or DECREASE (cold) a desired temperature can be obtained. Rotating the lever 90° locks the system in manual position. Automatic operation is resumed by returning the lever to the detent position.

COCKPIT TEMPERATURE CONTROL KNOB.
Controls the left mixing valve and cockpit temperature. (See cabin temperature control knob).

CABIN TEMPERATURE CONTROL KNOB.
Controls the right mixing valve via the corresponding mixing valve control unit.
The temperature can be varied from 18° to 29°C. When the knob is set against the dot on the panel, the temperature will stabilize at approx. 22°C.

FREON TEMPERATURE INDICATOR.
Indicates the saturation and superheat temperatures of the associated system:
Saturation temperature is the boiling point of the liquid in the evaporator.
Superheat is the rise in temperature of the gas above the boiling point of the liquid in the evaporator.

EVAPORATOR AIR INLET TEMPERATURE SWITCH
If ram air temperature is below 10° C this switch will cut out the freon system during flight.

FREON COMPRESSOR OVERHEAT LIGHT. (Amber, press to test).
Illuminates when the corresponding compressor oil temperature becomes too high and also when the pneumatic pressure becomes too low.

FREON COMPRESSOR OPERATING LIGHT. (Blue, press to test).
Illuminates when the corresponding compressor is in operation.

FREON COMPRESSOR SWITCH.
In position NORM the shutoff valve will open and and start the compressor if the pneumatic manifold is pressurized, the mixing valve is in the cool range, the condenser pressure and the evaporator temperature are within limits.

FREON COMPRESSOR DISCHARGE OVERTEMPERATURE SWITCH
Will stop the compressor if the outflow temperature is above 128°C. The compressor starts again when the temperature has decreased to 80°C.

CABIN COMPRESSOR OVERSPEED CUTOUT TEST BUTTON.
When the button is depressed it causes the corresponding cutout circuit to trip in the range 5000 to 15000 rpm.

CABIN COMPRESSOR RPM INDICATOR.
An automatic cutout circuit in the indicator will close the shutoff valve when the cabin compressor speed exceeds 50000 rpm. The compressor can be restarted by switching off the cabin compressor switch for a few seconds. If electrical power to the indicator should fail, the compressor shutoff valve will remain in the position it has been set.

CABIN COMPRESSOR SWITCH.
In position ON the corresponding shutoff valve will open and the cabin compressor start. However, during ground cooling operation with the recirculating fan switch in position AUTO and/or during overspeed cutout, the compressor will be automatically stopped.

1. General Description and Operation (See Figures 27-1 & 27-2)

A. Description

(1) The flight controls consist of the control surfaces, trim control surfaces, indicating and warning system, and the related mechanical, hydraulic, and electrical systems that control the airplane during flight or on the ground during landing and takeoff procedures.

(2) Control Surfaces

(a) The control surfaces and corresponding locations are as follows:

Control Surface	Location
Ailerons	Two on outboard trailing edge of each wing
Elevators	Trailing edge of horizontal stabilizer
Rudder	Trailing edge of vertical stabilizer
Flaps	Trailing edge of each wing inboard of ailerons
Wing slots	Inboard of engine pylons on each wing
Lateral control spoilers	Trailing edge of each wing, on upper surface forward of flaps, inboard of ailerons
Ground spoilers	Trailing edge of each wing, on upper surface forward of flaps, inboard of lateral control spoilers

(b) The ailerons provide lateral control of the airplane and are normally hydraulically actuated. The hydraulic components are controlled mechanically by the dual aileron control wheels in the flight compartment. The control tab on the trailing edge of each inboard aileron is hydraulically locked in faired position during hydraulic operation. If hydraulic pressure drops below approximately 1150 psi, the control tab is unlocked and becomes an aerodynamic boost control surface operated manually by the control wheels. Manual operation can be selected by closing a hydraulic shutoff valve that is controlled by a lever on the systems engineer's control pedestal. When the control tab is moved, aerodynamic forces on the tab move the aileron.

(f) A stabilizer motion warning is sounded when the horizontal stabilizer is being moved by either of the three methods of control or by the autopilot trim. The system provides a dual tone audible signal once for approximately each 1/2 degree of stabilizer movement.

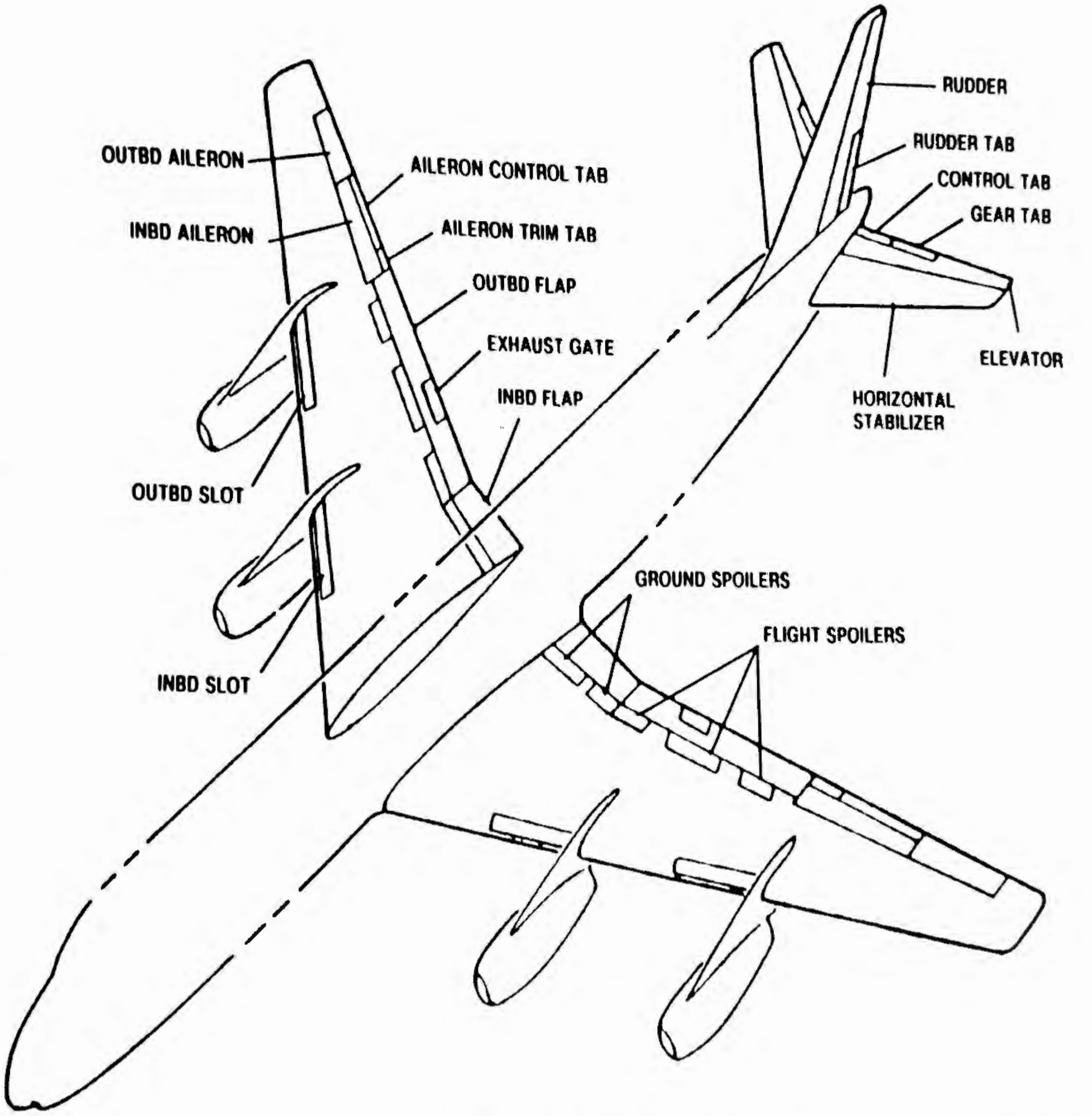
(g) A stall warning system is actuated if the airplane approaches a stall condition during flight. The system induces vibrations into the control columns to provide a positive warning that cannot be confused with other warning systems in the flight compartment.

2. Aileron and Tab Description and Operation (See Figure 27-3)

A. General

(1) The ailerons and tabs are movable control surfaces which provide lateral control of the airplane during flight. There are two ailerons attached to the trailing edge of each wing. A control tab and a trim tab is attached to the trailing edge of each inboard aileron. Movement of the ailerons and tabs is controlled by three subsystems: the aileron control system, the aileron hydraulic power shutoff system, and the aileron trim control system.

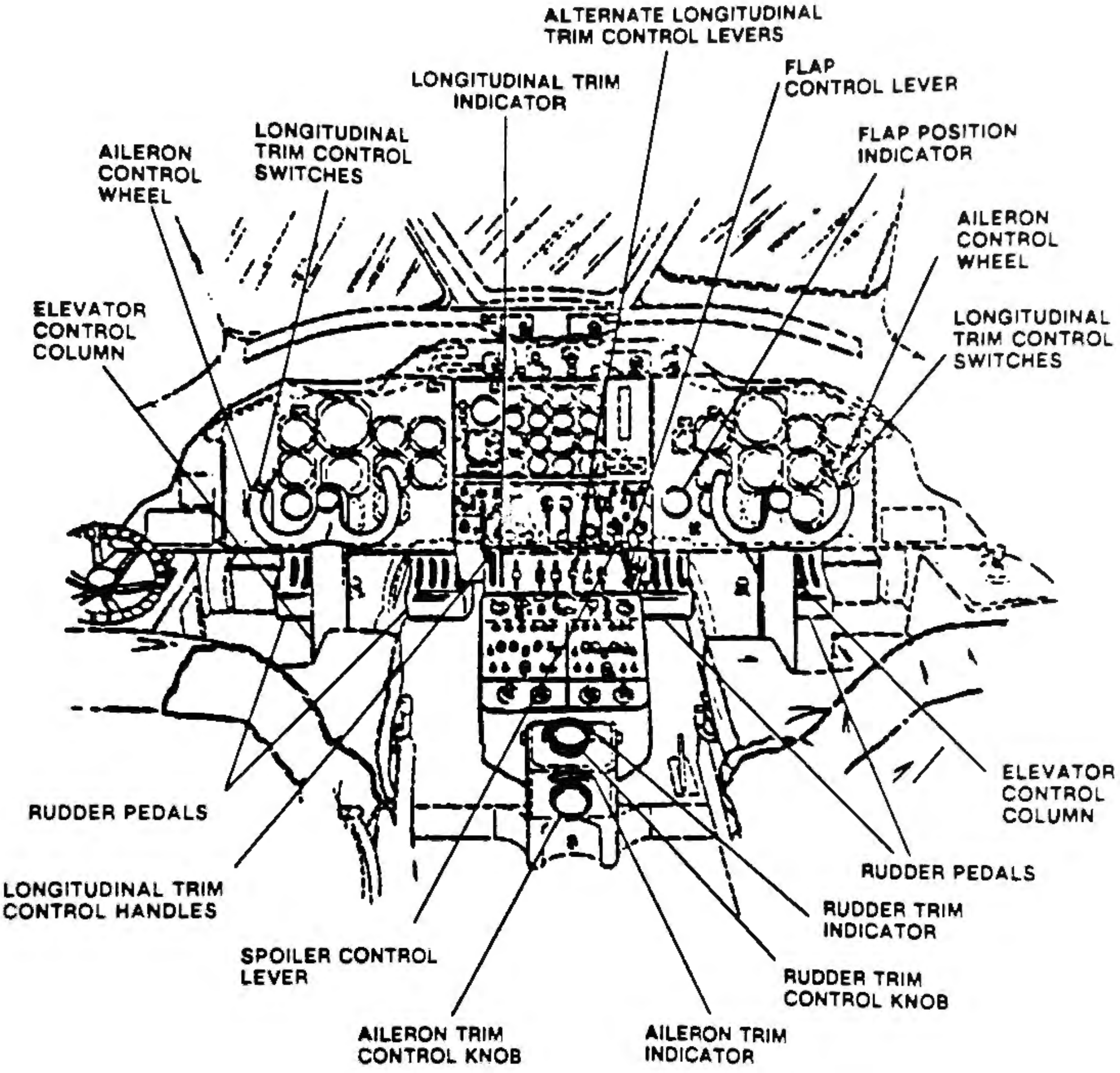
(2) The aileron control system is a hydraulically actuated, mechanically controlled system which controls the movement of the ailerons and aileron control tabs from the control wheels in the flight compartment. During normal operation, the control tabs are hydraulically locked in the neutral position. Control wheel movement is transmitted by cable systems to actuate hydraulic components which move the ailerons. If hydraulic pressure drops below approximately 1150 psi, or if the hydraulic power shutoff valve control lever is moved to the off position, hydraulic power is cut off and a power-to-manual reversion mechanism unlocks the control tab. Control wheel movement is then transmitted through the cable systems, the reversion mechanism, and mechanical linkage to move the aileron control tabs. Aerodynamic forces on the control tabs cause the ailerons to move. An aileron bus cable system interconnects the left and right inboard ailerons to minimize aileron up-float. If either side of the system becomes jammed, a torque tube and override mechanism allows the opposite side of the system to be operated.



DC-8 CONTROL SURFACES

FTX80218

Figure 27-1



FLIGHT CONTROLS AND INDICATORS --
FLIGHT COMPARTMENT

FTX80219

Figure 27-2

(b) The elevators provide longitudinal control of the airplane about the lateral axis and are operated by aerodynamic boost control surfaces. A control tab on the trailing edge of each elevator is deflected, and the aerodynamic forces on the tab move the elevator. The control tabs are controlled by the dual control columns in the flight compartment. A geared tab on each elevator trailing edge is mechanically linked to the horizontal stabilizer so that as the elevator moves, the geared tab is moved in the same direction as the control tab to provide additional aerodynamic control forces.

(c) The rudder provides directional control of the airplane about the vertical axis and is normally hydraulically actuated. The hydraulic components are mechanically controlled by dual rudder pedals in the flight compartment. The control tab on the rudder trailing edge is hydraulically locked in faired position during hydraulic operation. If hydraulic pressure drops below approximately 1150 psi, the control tab is unlocked and becomes an aerodynamic boost control surface. Manual operation may be selected by closing a hydraulic shutoff valve that is controlled by a lever on the systems engineer's control pedestal. The rudder is connected mechanically to the flap system so that, when the flaps are extended less than 10 degrees, rudder hydraulic pressure is reduced and the rudder stops are positioned to reduce rudder travel. When the flaps are extended 10 degrees or more, rudder travel is unrestricted.

(d) The flaps increase the lift of the wing when partially extended during the landing approach or takeoff and increase drag to reduce speed when fully extended during the landing. The flaps are hydraulically actuated, and the hydraulic components are controlled by the flap control lever on the pilot's control pedestal.

(e) The wing slots augment the flaps in increasing the lift of the wing. During normal flight with the flaps fully retracted, the slots are closed by doors that fair with the wing contour. When the flaps are extended during takeoff or landing procedures, the slot doors are opened. The doors are hydraulically actuated, and the hydraulic components are controlled by the flap control lever on the pilot's control pedestal.

(f) The ground spoilers supplement the flaps by increasing drag to reduce speed during the landing roll. The ground spoilers are actuated hydraulically and may be electrically or manually controlled. When the spoiler control lever, located on the control pedestal, is set in the armed position, the ground spoilers, with the lateral control spoilers, extend automatically when the main gear wheels spin after contact with the ground.

(g) The lateral control spoilers supplement the aileron in lateral control of the airplane at low speed when the landing gear is extended. The lateral control spoilers are hydraulically actuated and are controlled by the aileron control wheels in the flight compartment. The lateral control spoilers are also connected to the ground spoiler system so that they extend with the ground spoilers during landing roll.

(3) Trim Control Surfaces

(a) The aileron trim tabs and the horizontal stabilizer are adjustable trim control surfaces that provide a means of adjusting the aerodynamic characteristics of the main control surfaces.

(b) Aileron trim is obtained by rotating the aileron trim control knob on the pilot's control pedestal. This moves the aileron trim and load-feel mechanism to a new neutral position and moves the aileron trim tab up or down from the neutral position. During power operation, the repositioning of the trim and load-feel mechanism causes the hydraulic components to move the aileron up or down in the amount of trim selected. During manual control, the aileron control tab is moved along with the trim tab so that aerodynamic fores on the tabs move the aileron to the trimmed position.

(c) The horizontal stabilizer provides longitudinal trim and is controlled by the longitudinal trim control system. The system, which is hydraulically actuated, can be controlled manually by handles on the pilot's control pedestal or electrically by switches in the aileron control wheels. An alternate system of moving the stabilizer is electrically actuated and controlled by two levers on the pilot's control pedestal.

(d) Rudder trim is obtained by moving the rudder trim control knob on the pilot's control pedestal. This moves the rudder trim and load-feel mechanism and the rudder pedals to a new neutral position. During power operation, the hydraulic components move the rudder left or right in the amount of trim selected. During manual operation, the control tab on the rudder is moved so that aerodynamic forces on the tab move the rudder to the selected trim position.

(e) A pitch trim compensator system automatically applies corrective forces to the elevator control system to compensate for the pitching moment of the airplane which occurs as the airplane approaches the speed of sound. The electromechanical system repositions the elevator control column and load-feel centering mechanism according to static and pitot air pressure information fed into a computer.

(4) Indicating and Warning Systems

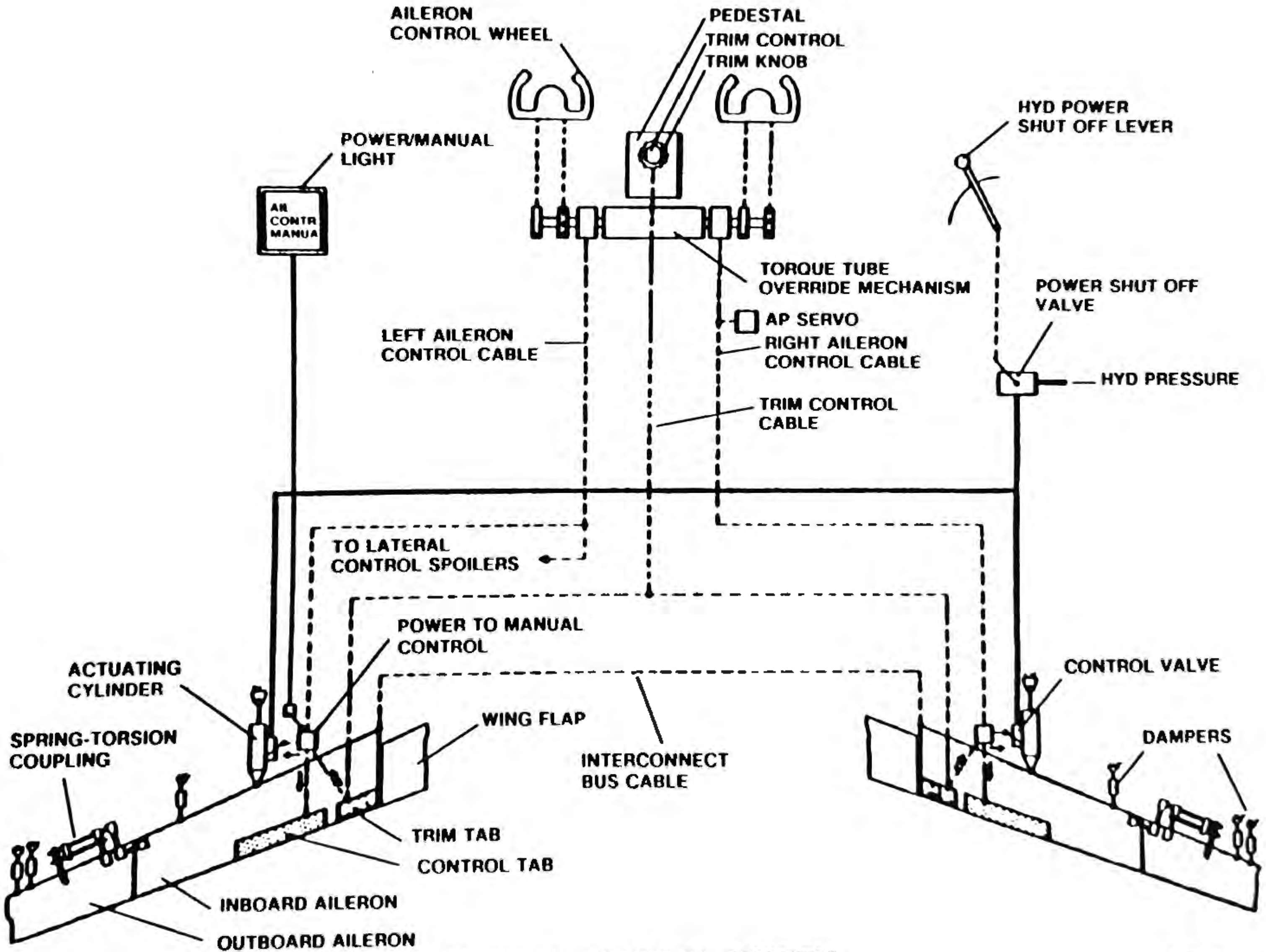
(a) Indicating and warning systems are used to show the position of the trim control surfaces and to provide warning when certain controls are being used or should not be used.

(b) Mechanical indicators on the control pedestal show the amount of trim for the ailerons, rudder, and horizontal stabilizer. A remote electrical indicator on the instrument panel indicates the position of the left and right flaps.

(c) Indicating lights in the flight compartment shown when the rudder and the aileron control systems are in the manual mode of operation; when the spoilers are not in the retracted position; when the pitch trim compensator actuator is 80 percent extended and when the pitch trim compensator computer is disabled.

(d) A takeoff warning system will sound an intermittent audible warning if the engine throttles are advanced for takeoff when the flaps or spoilers are not in the proper position for takeoff.

(e) A landing gear warning system will sound a continuous audible warning if the flaps are extended past the approach position with the landing gear not down and locked.



AILERON CONTROL SYSTEM

FTX80223

Figure 27-3

(3) The aileron hydraulic power shutoff system is a mechanical system which controls the supply of hydraulic pressure to the aileron control system hydraulic components. The system consists of a hydraulic power shutoff valve connected by cable system to a control lever in the flight compartment. The shutoff valve automatically shuts off hydraulic pressure to the aileron components when the hydraulic power system pressure drops below approximately 1150 psi. The system may be used to shift the aileron control system to manual operation by moving the shutoff valve control lever to the off position.

(4) The aileron trim control system is a mechanical system which changes the neutral position of the aileron load-feel mechanism and moves the trim tab on each inboard aileron to provide aileron trim. The load-feel mechanism and trim tabs are connected by cable systems to a trim control knob in the flight compartment. Rotating the trim control knob moves the load-feel mechanism to a new neutral position, changing the neutral position of the aileron control wheels. Rotating the trim control knob also moves the aileron trim tabs and positions a trim indicator pointer to show the amount of trim.

3. Aileron Control System - Description and Operation (See Figures 27-4 & 27-5)

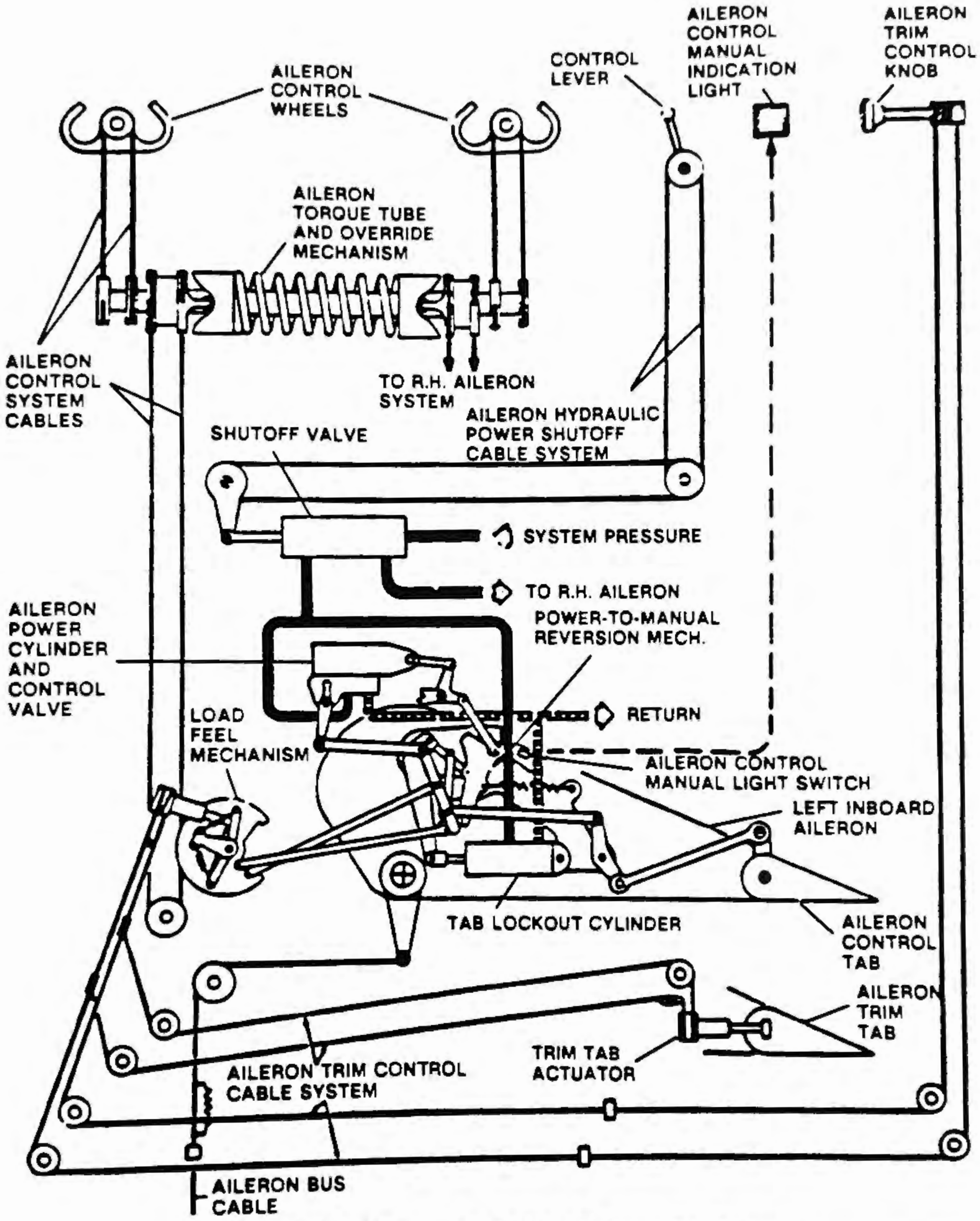
A. General

(1) The aileron control system is a hydraulically actuated, mechanically controlled system that controls the movement of the ailerons and the aileron control tabs. The system consists of the following major components:

Component	Location
Ailerons	Two (inboard and outboard) on trailing edge of each wing, outboard of flaps.
Aileron control tabs	One on trailing edge of each inboard aileron, outboard of trim tab.
Aileron control wheels	One on each control column in flight compartment.
Aileron torque tube and override mechanism	Below flight compartment floor panels, aft of pilot's control pedestal.
Power-to-manual reversion mechanism	One in leading edge of each inboard aileron.
Power cylinders and control valves	One attached to wing rear spar forward of each inboard aileron.

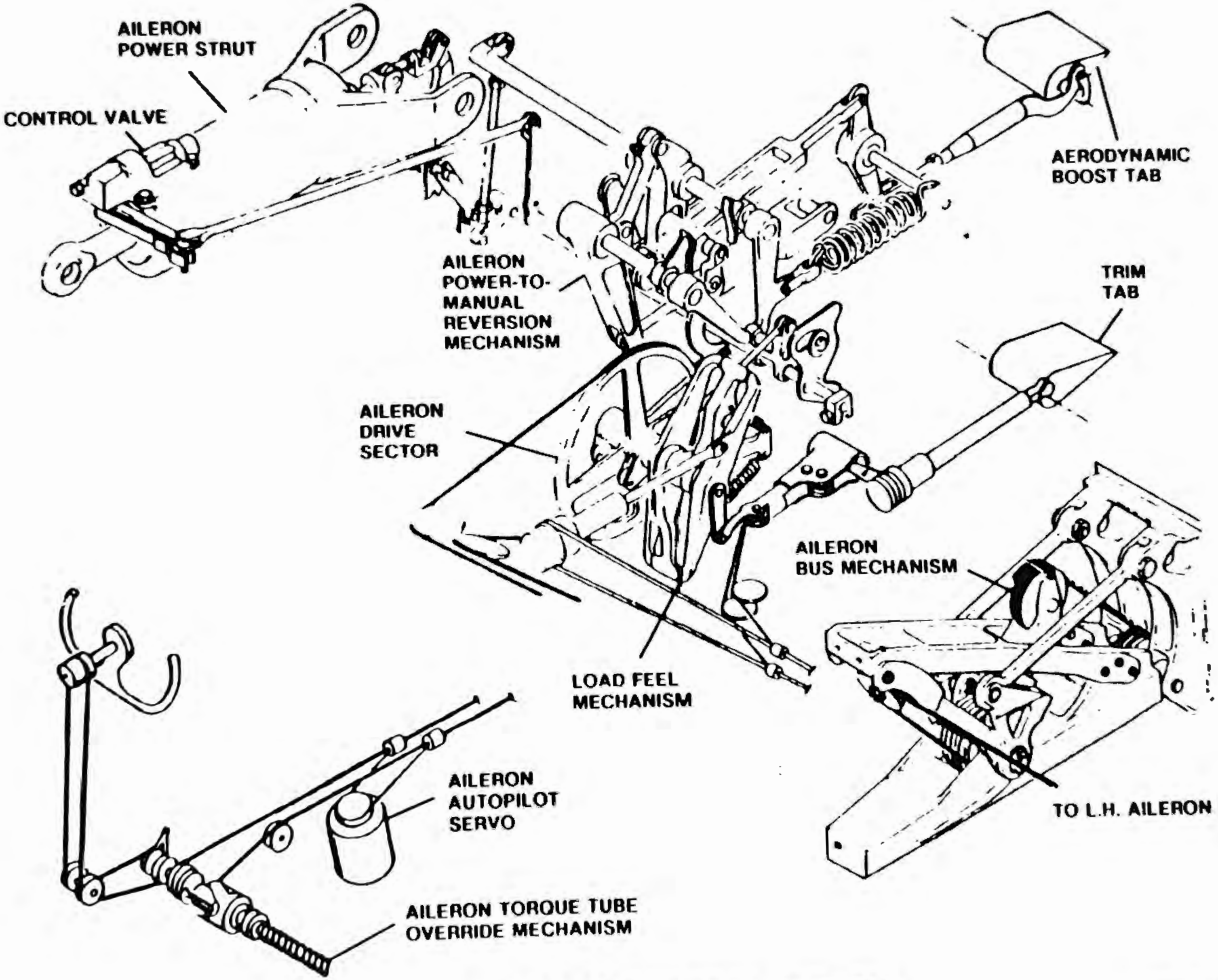
Tab lockout cylinders	One in leading edge of each inboard aileron.
Aileron dampers	Two attached to leading edge of each outboard aileron and one attached to leading edge of each inboard aileron.

(2) The ailerons and aileron control tabs are controlled by the aileron contorl wheels in the flight compartment. Each control wheel is connected by a two-way cable system to fixed drums on the aileron torque tube. The override mechanism, mounted on the aileron torque tube, is conencted by two-way cable systems, routed through the fuselage and along the wing to a drive sector forward of each inboard aileron. Each drive sector is connected by mechanical linkage, through the power-to-manual reversion mechanism to the aileron hydraulic control valve and also to the aileron control tab. The inboard and outboard ailerons on each wing are interconnected by a spring torsion coupling. An aileron bus cable system interconnects the inboard ailerons to minimize upward travel of the ailerons in the event that the ailerons on both wings attempt to move upward simultaneously. The bus system consists of spring-loaded pulley mechanisms attached to the inboard ailerons and interconnected by a single cable routed along the wing rear spar.


AILERON CONTROL MANUAL INDICATION LIGHT
AILERON TRIM CONTROL KNOB
CONTROL LEVER
AILERON CONTROL WHEELS
AILERON TORQUE TUBE AND OVERRIDE MECHANISM
AILERON CONTROL SYSTEM CABLES
TO R.H. AILERON SYSTEM
AILERON HYDRAULIC POWER SHUTOFF CABLE SYSTEM
SHUTOFF VALVE
SYSTEM PRESSURE
TO R.H. AILERON
POWER-TO-MANUAL REVERSION MECH.
AILERON POWER CYLINDER AND CONTROL VALVE
LOAD FEEL MECHANISM
RETURN
AILERON CONTROL MANUAL LIGHT SWITCH
LEFT INBOARD AILERON
TAB LOCKOUT CYLINDER
AILERON CONTROL TAB
AILERON TRIM TAB
TRIM TAB ACTUATOR
AILERON TRIM CONTROL CABLE SYSTEM
AILERON BUS CABLE

AILERON AND TAB SYSTEM -- SCHEMATIC FTX80220

Figure 27-4



AILERON CONTROL SYSTEM

FTX80222

Figure 27-5

B. Component Description

(1) Ailerons and Control Tabs (See Figure 27-6)

(a) There are two ailerons hinged to the rear spar of each wing, outboard of the flaps. Aileron travel is 18 3/4 degrees (inboard aileron) and 16 1/4 degrees (outboard aileron) up or down from neutral position. Both ailerons are aerodynamically balanced. Mass balance weights are installed in the leading edge sections for prevention of flutter. Hoisting points are provided on each aileron.

(b) Only the inboard ailerons are directly connected to the aileron control system. The outboard ailerons are connected to the inboard ailerons by preloaded spring torsion coupling. Each coupling preload is set to limit the maximum hinge moment at the outboard aileron so that full deflection is obtained only at low speeds. The two ailerons operate together at low speeds, but the torque applied by the coupling causes the outboard aileron to lag with progressively less deflection as speed increases.

(c) Each inboard aileron has a trim tab and a control tab. The outboard tab is the control tab. Control tab travel is 24 1/2 degrees up and 15 degrees down from the faired position. Each control tab is linked to the power-to-manual reversion mechanism by a pushrod attached to a horn at the inboard hinge line. Control tabs are interchangeable without rebalancing the aileron.

(2) Aileron Control Wheels

(a) There are two aileron control wheels located in the flight compartment, one on each control column. A microphone switch, autopilot release switch, and dual longitudinal trim control switch are installed in the outboard horn of each wheel. Electrical wiring from the switches is routed through the hub of the wheel and down the control column.

(b) Each wheel is attached to a drum in the head of the control column. A cable system is routed from the drum, down through the control column, to the aileron torque tube. Stops on the drum limit rotation of the wheel to approximately 135 degrees either way from neutral position.

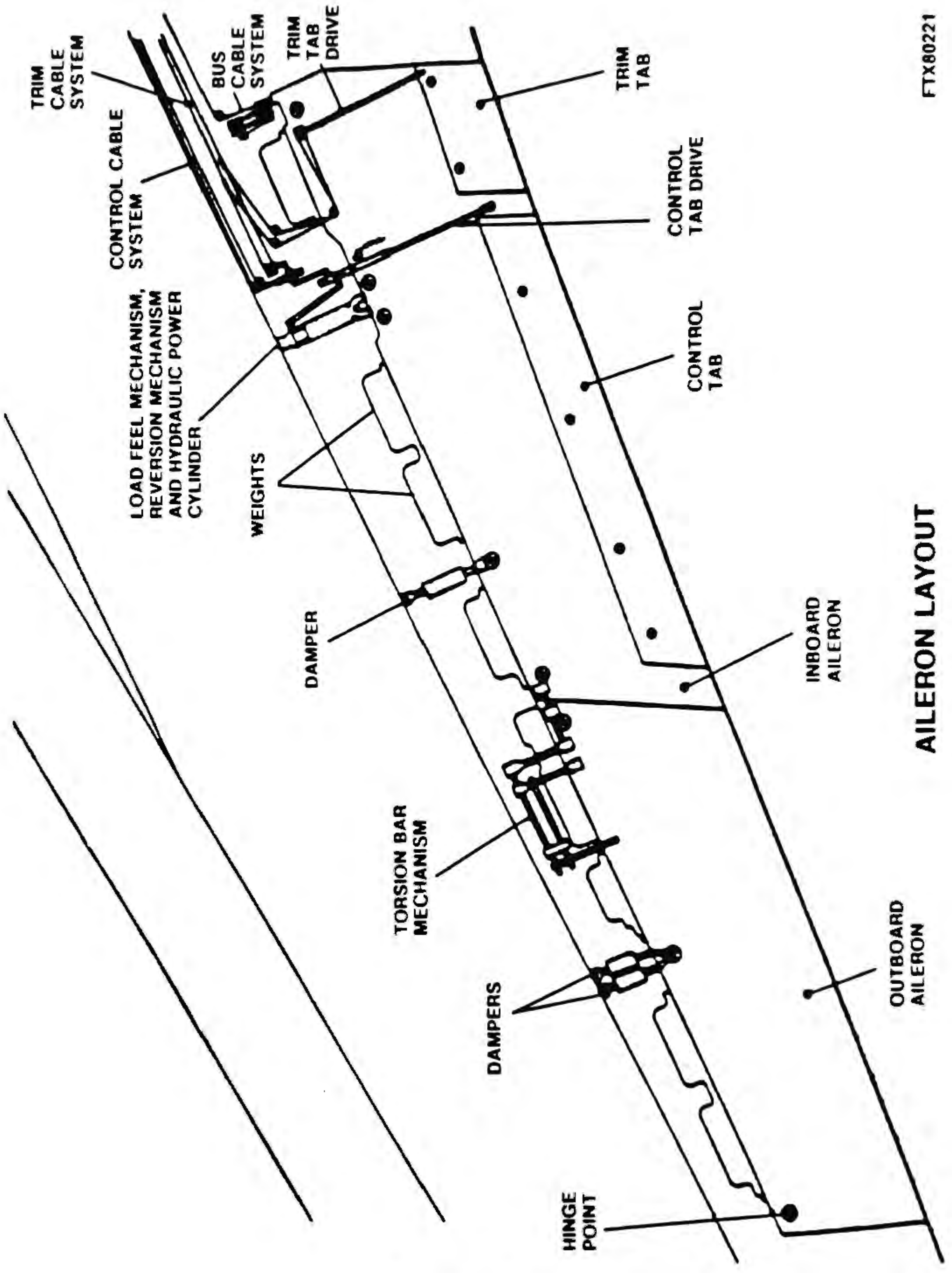
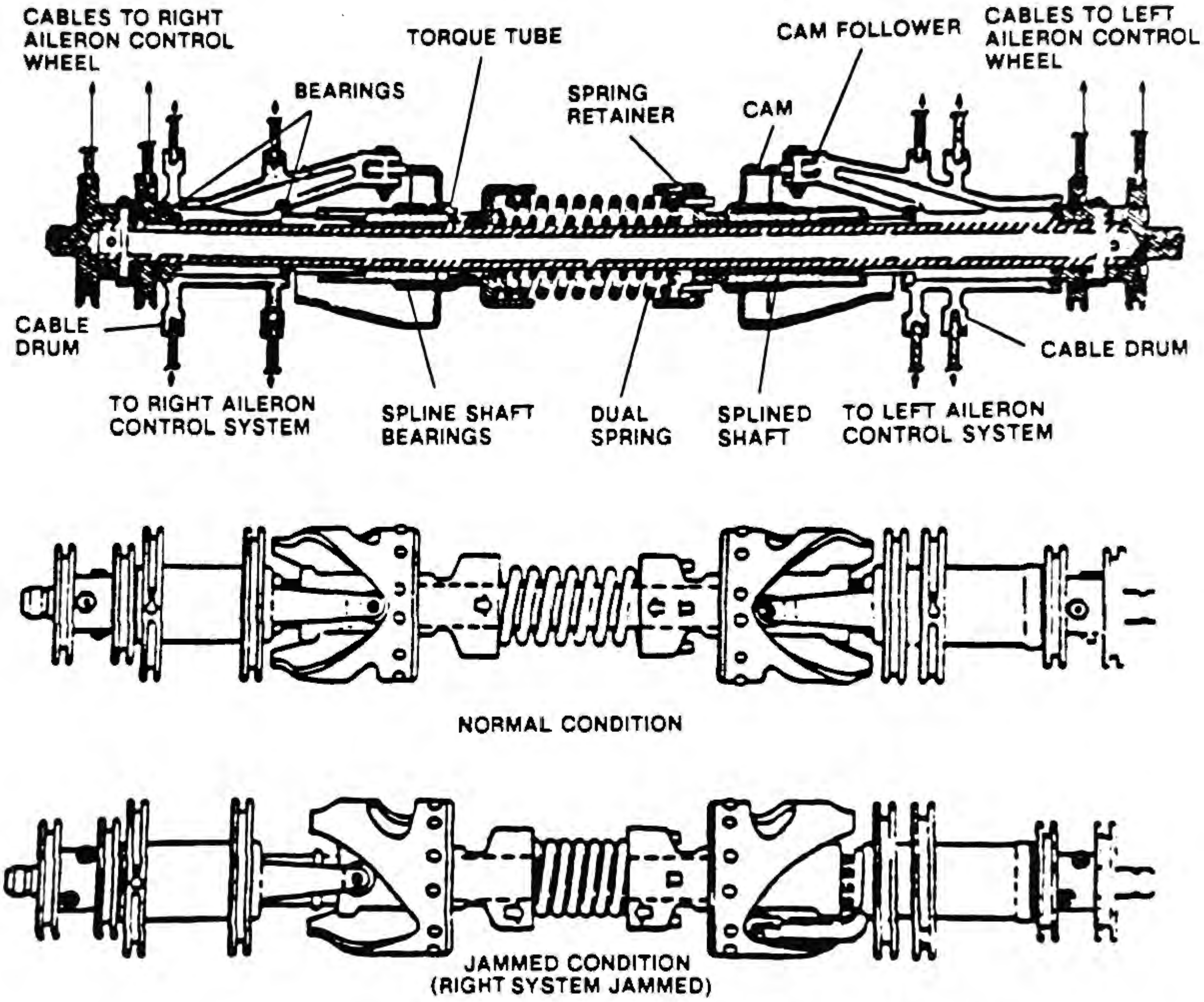

TRIM CABLE SYSTEM
CONTROL CABLE SYSTEM
LOAD FEEL MECHANISM, REVERSION MECHANISM AND HYDRAULIC POWER CYLINDER
BUS CABLE SYSTEM
TRIM TAB DRIVE
TRIM TAB
CONTROL TAB DRIVE
CONTROL TAB
WEIGHTS
DAMPER
INBOARD AILERON
TORSION BAR MECHANISM
DAMPERS
OUTBOARD AILERON
HINGE POINT
AILERON LAYOUT
FTX80221

Figure 27-6

(3) Aileron Torque Tube and Override Mechanism (See Figure 27-7)

(a) The aileron torque tube and override mechanism is located below the flight compartment floor, aft of the pilot's control pedestal. The mechanism consists of a torque tube with dual cable drums bolted at each end and an override mechanism. The torque tube interconnects the two aileron control wheels so that the ailerons may be controlled by either control wheel. The override mechanism allows the control wheels to operate the aileron system on one side if the system on the opposite side becomes jammed.

(b) The override mechanism consists of two cable drum and cam follower assemblies, two cams, and a dual spring. The two cams are attached to bearing which slide along a splined shaft attached to the torque tube. The cable drums are positioned on the tube so that the cam followers which are integral parts of the drums, are seated in the detents of the cams. The dual spring is located on the torque tube between two spring retainers attached to the cams and exert a force against the cams to keep the cam followers seated in the detents. The drums on the override mechanism are connected by cable systems to the left and right aileron drive sectors. The drums bolted to the outer ends of the torque tube are connected by cable systems to the aileron control wheels.



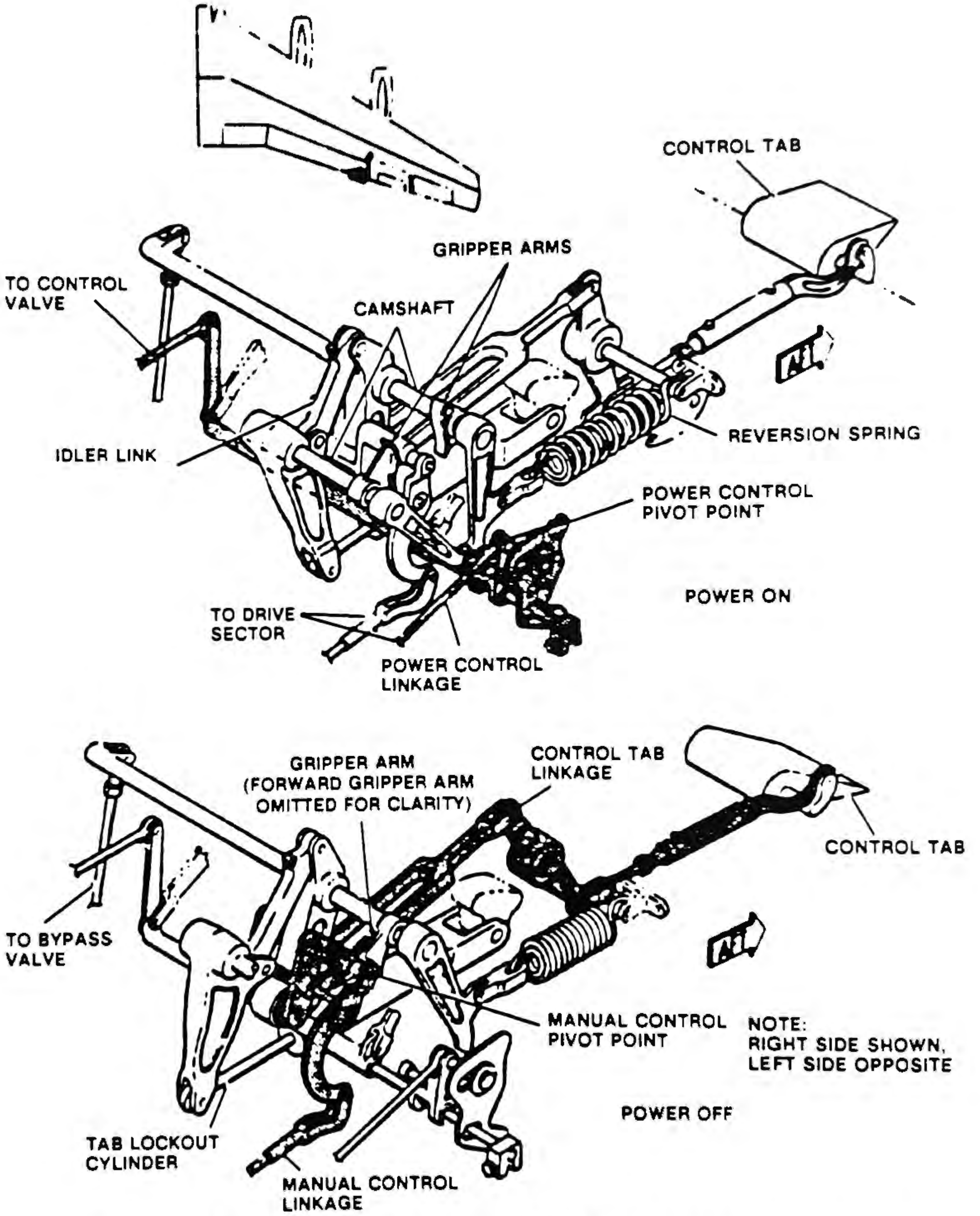
AILERON TORQUE TUBE AND OVERRIDE MECHANISM FTX80224

Figure 27-7

(4) Power-to-Manual Reversion Mechanism (See Figure 27-8)

(a) There are two aileron power-to-manual reversion mechanism, one located in the leading edge of each inboard aileron. The mechanism automatically shifts the aileron control system from power operation to manual operation if the hydraulic pressure from the hydraulic power system drops below 1150 (±50) psi. The mechanism also shifts the aileron control system from power to manual operation when the aileron hydraulic power shutoff valve control lever is moved to the off position or from manual to power operation when the control lever is moved to the on position.

(b) The mechanism consists of a support, two gripper arms with cams, two camshafts, an idler link, pivot link, reversion spring, and connecting linkage. The camshafts are installed on the support which is attached to the aileron spar. The gripper arms with their cams are installed on the camshafts and are connected at the upper end by the idler link. The pivot link is mounted between the gripper arms and is connected by mechanical linkage to the aileron drive sector, power cylinder control valve, and the load-feel mechanism. The reversion spring is connected between a bracket on the aileron structure and the aft gripper arm. The aft gripper arm is connected by pushrod to the power cylinder bypass valve. The forward gripper arm is connected to the tab lockout cylinder piston.



AILERON POWER-TO-MANUAL REVERSION MECHANISM FTX80225
Figure 27-8

(5) Aileron Tab Lockout Cylinder (See Figure 27-9)

(a) There is one aileron tab lockout cylinder located adjacent to the reversion mechanism in each inboard aileron. The cylinder positions the gripper arms in the reversion mechanism to lock the aileron control tab in the faired position during power operation. During manual operation, the cylinder is maintained in the extended position by the reversion spring and the control tab is free.

(b) The tab lockout cylinder consists of a cylinder, piston, and a bypass valve. The cylinder is attached to the aileron structure. The piston is connected to one of the gripper arms in the reversion mechanism. The bypass valve is spring-loaded to the bypass position.

(6) Aileron Power Cylinder and Control Valve (See Figure 27-10)

(a) An aileron power cylinder and control valve is located adjacent to the reversion mechanism in the leading edge of each inboard aileron. The control valve directs hydraulic pressure to the power cylinder which drives the aileron during power operation. The cylinder contains a blowback valve and a bypass valve. The blowback valve relieves excessive hydraulic back pressure in the cylinder caused by air loads on the aileron. The bypass valve allows circulation of fluid through the cylinder during manual operation.

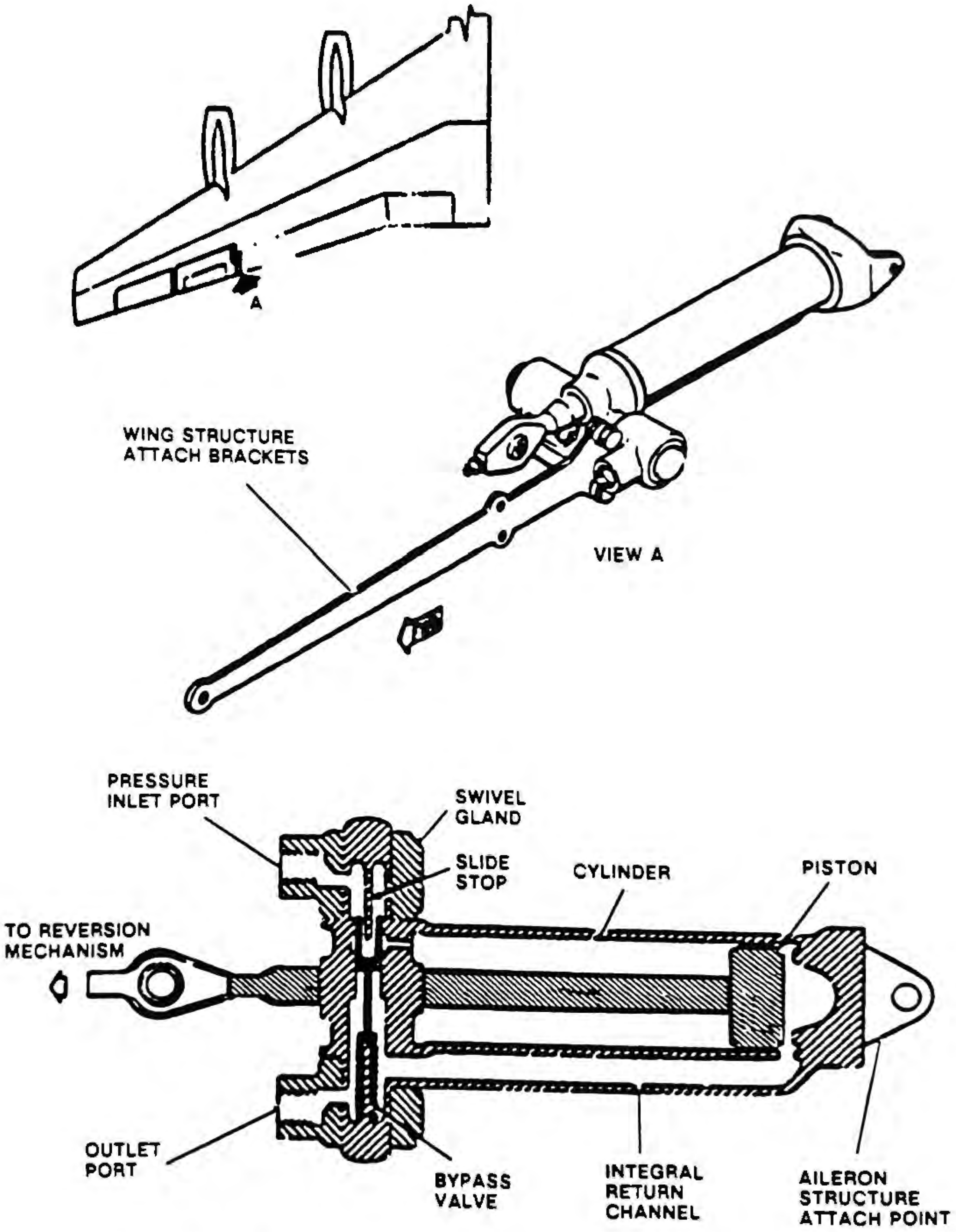
(b) The power cylinder consists of a barrel, piston, bypass valve, and blowback valve. Trunnion-type fittings on the aft end of the barrel are attacehd to the aileron structure. The piston, which extends through glands at each end of the barrel, is attached at the forward end to a bracket on the wing rear spar. The blowback and bypass valves are located in the hollow piston. A crank at the aft end of the bypass valve slide is connected to the reversion mechanism linkage.

C. Operation

(1) Hydraulic Power Operation (See Figure 29-12)

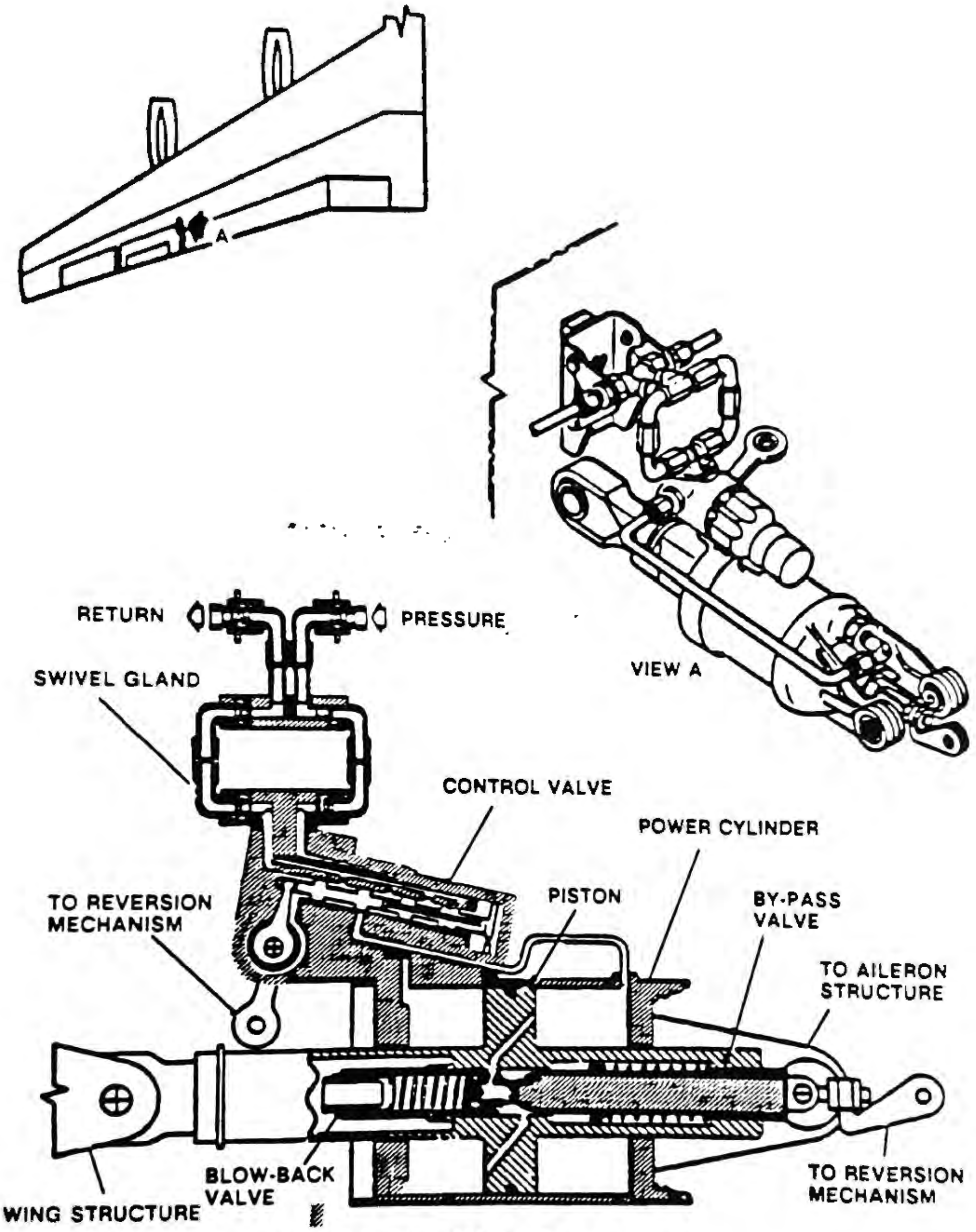
(a) The aileron hydraulic power shutoff system controls hydraulic supply from the main hydraulic power system to the aileron hydraulic components. When the aileron hydraulic power shutoff valve control lever is in the on position, hydraulic pressure is directed to a pressure-operated slide valve in the shutoff valve. When system pressure reaches 1500 (±200) psi, the shutoff valve directs pressure to the tab lockout cylinders and the power cylinder control valves.

(b) Each tab lockout cylinder piston is maintained in the extended position by the reversion spring in the power-to-manual reversion mechanism. When hydraulic pressure is directed to the lockout cylinder, tension of the reversion spring is overcome and the piston retracts. The gripper arms in the reversion mechanism lock the aileron control tab in the faired position and free the control valve linkage. When either aileron control wheel is rotated, the cable systems rotate the aileron drive sectors. The drive sectors move the mechanical linkage to actuate the power cylinder control valves in the selected direction. The control valves direct hydraulic pressure to the power cylinders which drive one aileron up and the opposite aileron down.



AILERON TAB LOCKOUT CYLINDER -- SCHEMATIC FTX80226

Figure 27-9



AILERON POWER CYLINDER
AND CONTROL VALVE -- SCHEMATIC

FTX80227

Figure 27-10

(c) The control valve is mounted on top of the power cylinder barrel. Internal passages connect the valve to the forward side of the power cylinder piston and to a flexible hydraulic lines installed on top of the valve. A port on the forward end of the valve is connected by a hydraulic line to the aft side of the power cylinder piston. The flexible hydraulic lines act as a flexible connector between the control valve and the hydraulic system pressure and return lines. The slide of the control valve is connected by mechanical linkage through the power-to-manual reversion mechanism to the aileron drive sector.

(7) Aileron Hydraulic System Check Valves

(a) There are two reverse flow-type check valves included in the aileron hydraulic system, one lcoated upstream of each aileron power cylinder control valve. Each check valve is attached to the wing rear spar adjacent to the power cylinder. The valve isolate back surges of hydraulic pressure caused by a delay in the operation of the power cylinder blowback valves.

(8) Aileron Hydraulic System Filters

(a) Two 10-micron hydraulic filters are included in the aileron hydraulic system, one upstream of each check valve. The filters are attached to brackets on the wing rear spar, adjacent to the aileron drive sectors.

(b) Each filter consists of a housing, filter head, and a magnetic drain plug. The filter head has two ports, one marked inlet and one marked outlet.

(9) Aileron Dampers (See Figure 27-11)

(a) There are six aileron dampers, two located at the leading edge of each outboard aileron and one located at the leading edge of each inboard aileron. The dampers prevent rapid movement of the ailerons that may be caused by flutter during flight or by gusts of wind when the airplane is on the ground. The inboard aileron dampers are supplemented by the aileron power cylinders.

the left and right aileron hydraulic components. A yoke on the exposed end of the manual slide valve piston is connected by mechanical linkage to the cable system.

B. Operation

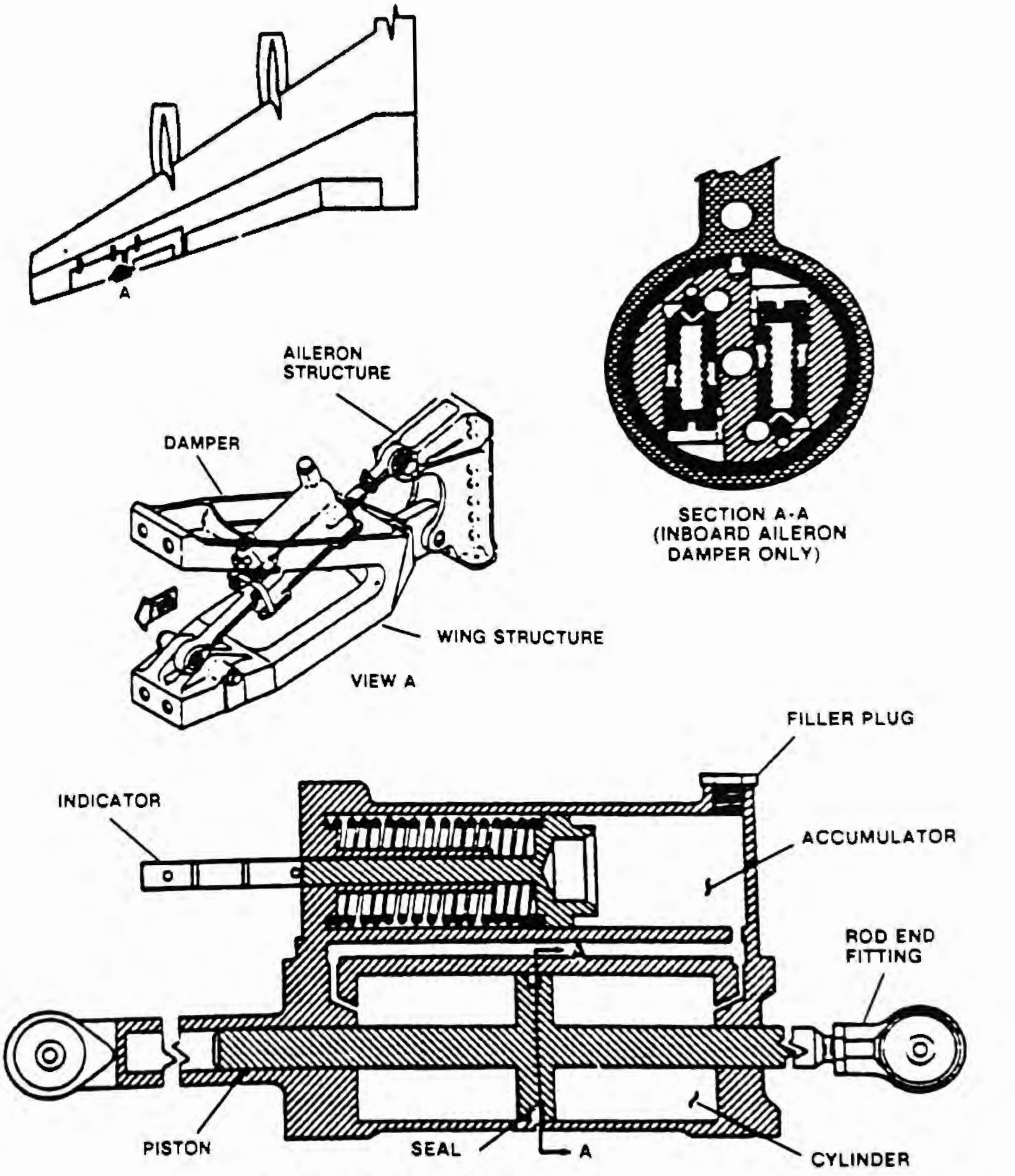
(1) Hydraulic pressure form the main hydraulic power system is supplied through the shutoff valve filter to the manual slide valve and the automatic slide valve. If the aileron hydraulic power shutoff valve control lever is moved to the off position, the cable system and mechanical linkage will push the manual slide valve piston, unseating the valve and allowing pressure to be bypassed to the system return lines. This reduces the pressure behind the automatic slide valve piston, allowing the spring-loaded slide to close. Hydraulic pressure is shut off from the aileron hydraulic components and the aileron control system reverts to manual operation.

(2) When the aileron hydraulic power shutoff valve control lever is moved to the on position, the cable system and mechanical linkage pull the manual slide valve piston away from the valve. When hydraulic pressure is sufficient to overcome the manual slide valve spring tension, the valve is reseated and pressure is directed to the automatic slide valve. Tension of the automatic slide valve spring is overcome and the slide is moved to open passages to the outlet ports that supply the aileron hydraulic components. The shutoff valve is preset so that a pressure of 1500 (±200) psi is required to open the valve to the aileron components.

(3) If hydraulic pressure to the shutoff valve drops below 1150 (±50) psi when the control lever is in the on position, the manual slide valve spring unseats the valve, the automatic slide valve moves to the closed position, and pressure is bypassed to the system return lines. Hydraulic pressure is automatically shut off from the aileron components and the aileron control system reverts to manual operation.

(b) Each damper consists of a cylinder and an accumulator combined in a single housing. The cylinder is in the lower portion of the housing A piston is located centrally in the cylinder with the aft end extending through the housing. A rod end fitting on the aft end of the piston is attached to the aileron structure. The forward end of the piston fits inside a hollow casing which forms the forward end of the cylinder. The forward end of the housing is attached to the wing structure forward of the aileron hinge. A seal around the piston prevents leakage of hydraulic fluid from one side of the piston to the other.

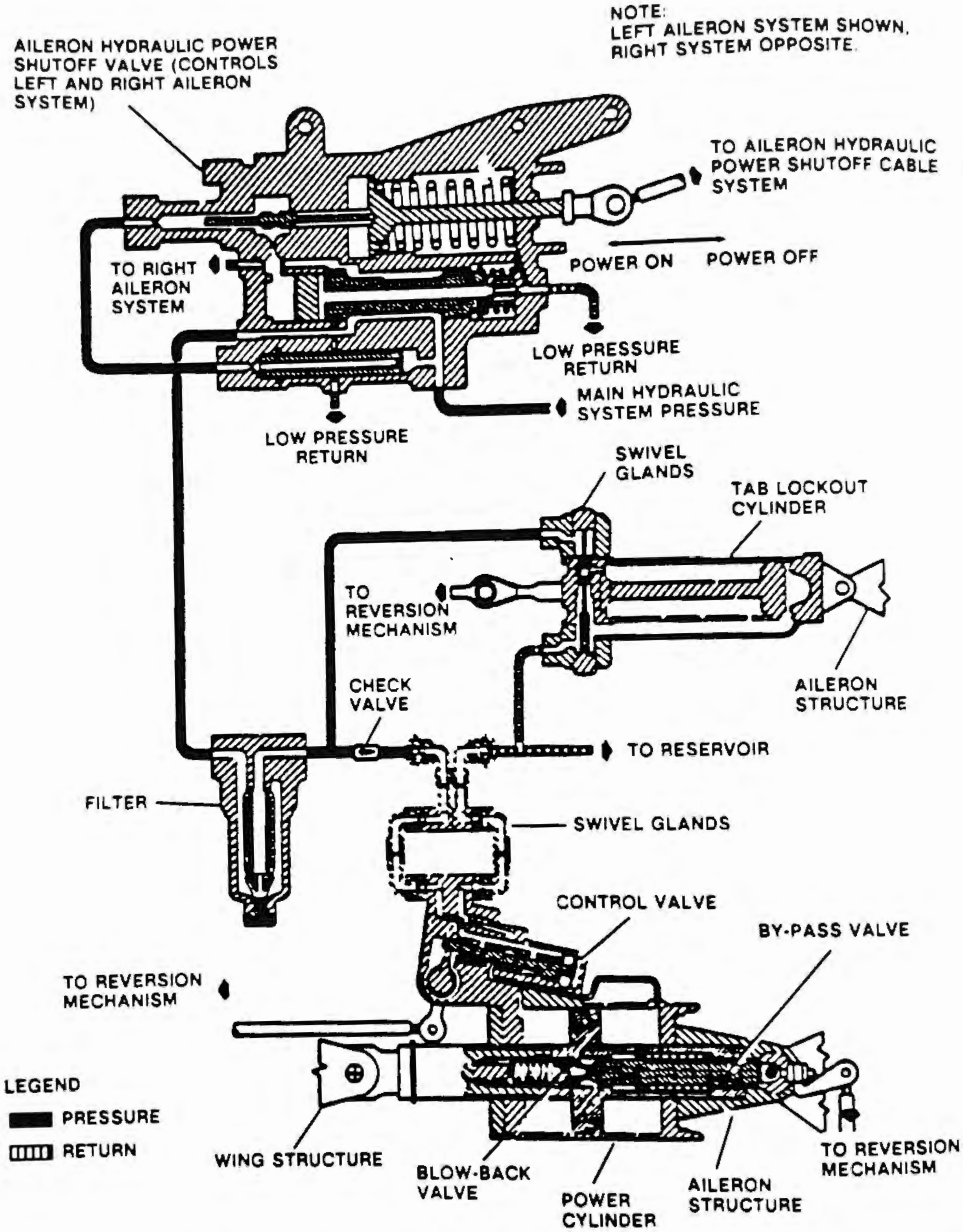
(c) The accumulator is located in the upper portion of the housing. Internal passages between the accumulator and the cylinder admit fluid to both sides of the cylinder piston. Hydraulic fluid level in the damper is indicated by the position of notches on the exterior portion of an indicator piston. The dampers are independent of the hydraulic system. A filler plug is provided on the top of the housing to replenish the supply of hydraulic fluid in the accumulator.



AILERON DAMPERS -- SCHEMATIC

FTX80228

Figure 27-11



AILERON HYDRAULIC SYSTEM -- SCHEMATIC

Figure 27-12

(2) Manual Operation

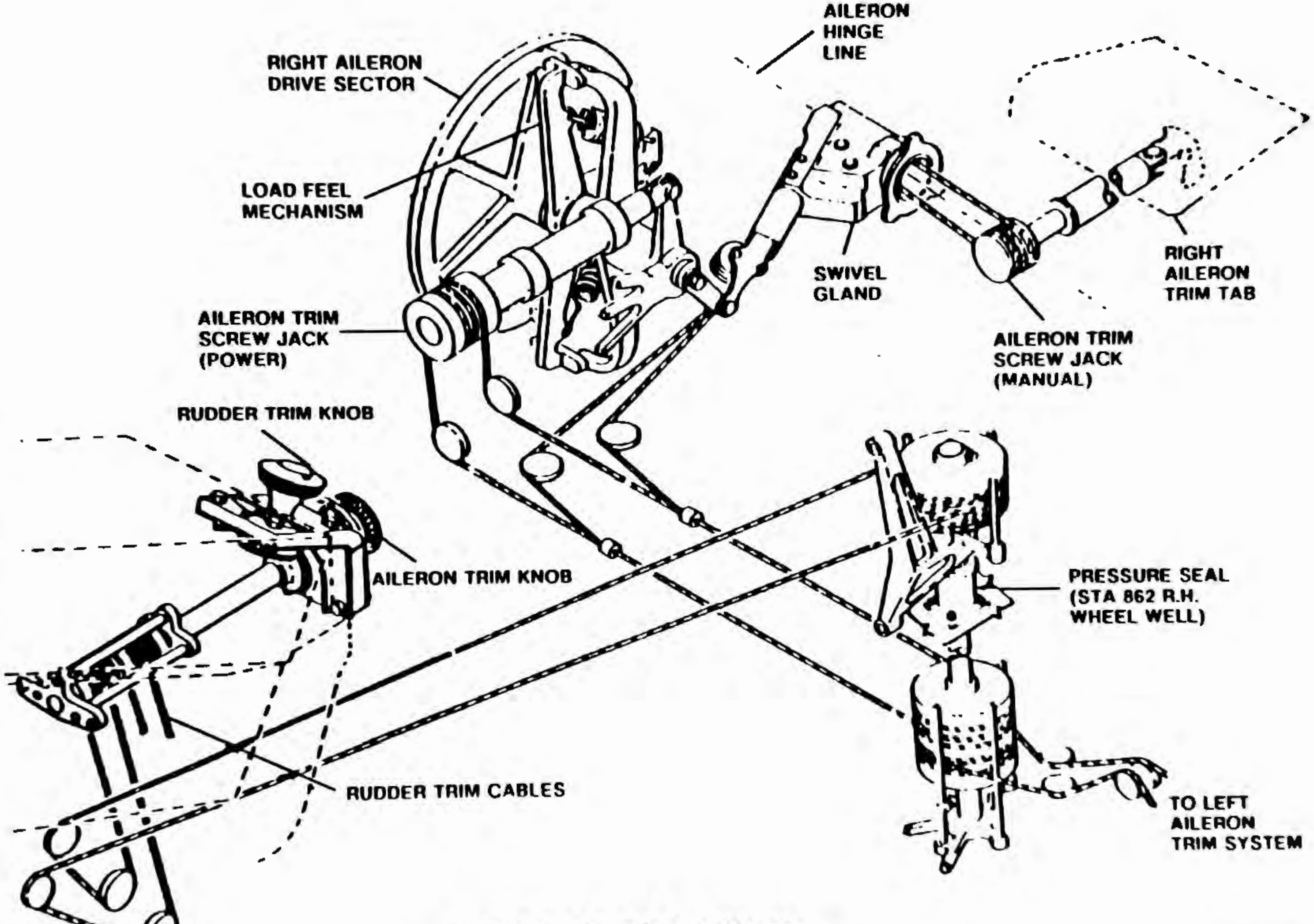
(a) If hydraulic pressure from the main hydraulic power system drops below 1150 (±50) psi, the pressure-operated slide valve in the shutoff valve will close and shutoff pressure to the aileron control system hydraulic components. When hydraulic pressure is removed from the tab lockout cylinder, the cylinder piston extends, causing the gripper arms in the reversion mechanism to free the control tab and lock the power cylinder control valve linkage. Aileron control wheel movement is then transmitted directly through mechanical linkage to move one aileron control tab up and the opposite control tab down. Aerodynamic forces on the tabs move the ailerons.

(b) A switch is actuated by the linkage from the reversion mechanism to the power cylinder bypass valve so that when the system reverts from power to manual operation, an aileron control manual light in the flight compartment comes on. When the system returns to power operation the light goes off. Manual operation may also be selected by moving the aileron hydraulic power shutoff control lever to the off position.

(3) Aileron Torque Tube and Override Mechanism

(a) In normal operation, when either aileron control wheel is rotated. a cable system rotates the aileron torque tube. The override mechanism rotates with the torque tube and drives the cable systems to the aileron drive sectors. The drive sectors operate the aileron hydraulic components or the control tab depending on mode of operation.

(b) If one side of the system becomes jammed, the corresponding cable system will prevent the torque tube from rotating with normal force applied to the control wheel. The override mechanism is adjusted so that a force of 400 to 490 inch-pounds is required at the control wheel to overcome the force exerted by the spring against the cams. When this extra force is applied to the control wheel, the cam follower on the jammed side forces the cam to slide along the splined shaft of the torque tube, and allows the torque tube to rotate to operate the opposite cable system.


AILERON HINGE LINE
RIGHT AILERON DRIVE SECTOR
LOAD FEEL MECHANISM
SWIVEL GLAND
RIGHT AILERON TRIM TAB
AILERON TRIM SCREW JACK (POWER)
AILERON TRIM SCREW JACK (MANUAL)
RUDDER TRIM KNOB
AILERON TRIM KNOB
PRESSURE SEAL (STA 862 R.H. WHEEL WELL)
RUDDER TRIM CABLES
TO LEFT AILERON TRIM SYSTEM

AILERON TRIM SYSTEM

FTX80232

Figure 27-15

(4) Aileron Dampers

(a) The aileron dampers resist the rapid movement of the ailerons. When the aileron is moved, the damper piston moves along the cylinder. Hydraulic fluid displaced from one side of the piston is forced through the narrow internal passages of the damper to the opposite side of the piston. The fluid and the size of the internal passages resist the movement of the piston.

(b) The force required to move the piston is equal to the internal resistance of the damper and is proportional to the speed of the motion. Normal movement of the ailerons is slow and is met with little resistance from the dampers. The more rapid the motion, the greater the resistance applied to the piston.

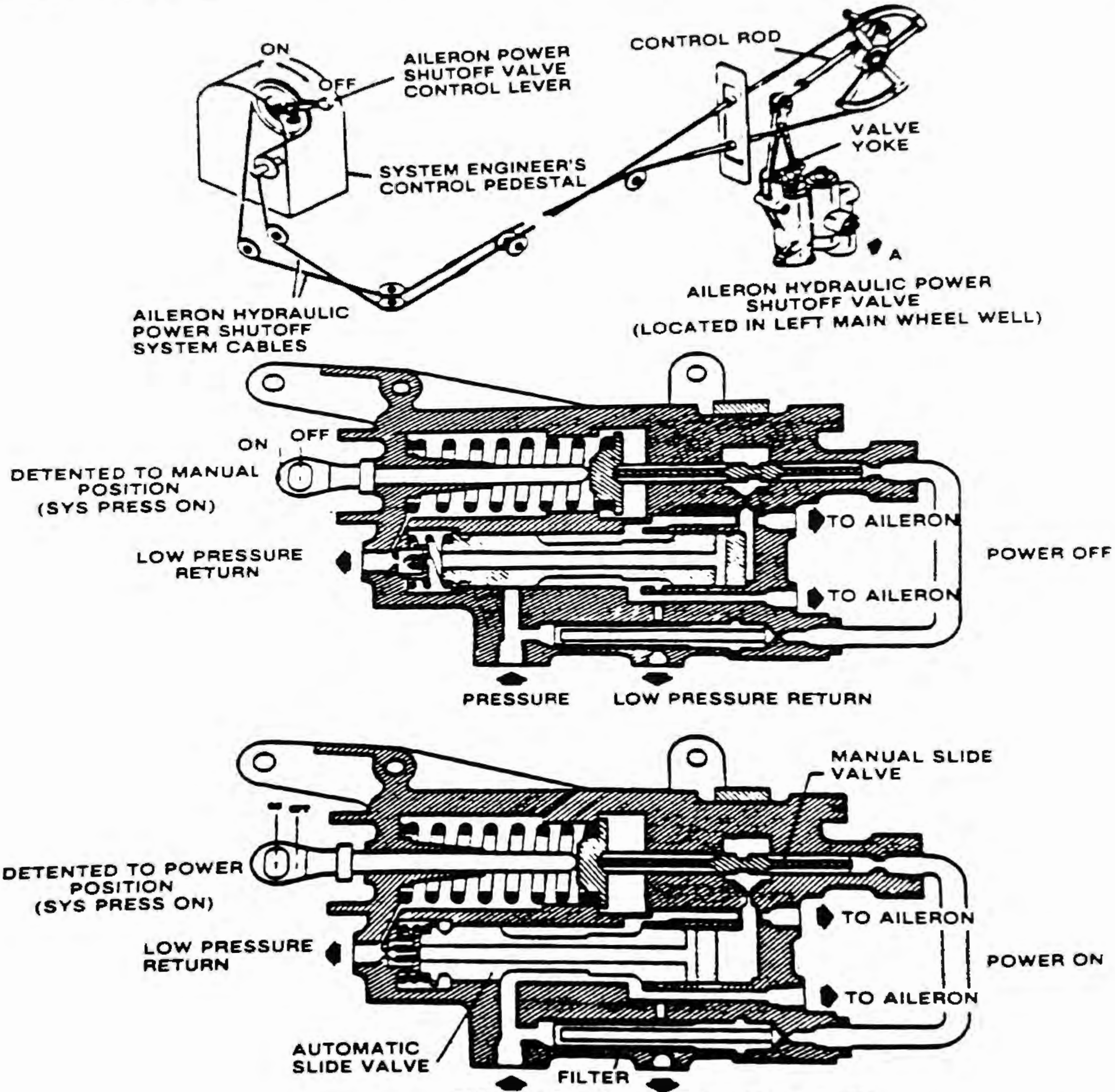
(c) The damper at each inboard aileron is supplemented by the aileron power cylinder. A bypass valve is incorporated in the piston of each inboard aileron damper to prevent overload of the damper in the event of power cylinder failure at extreme travel.

4. Aileron Hydraulic Power Shutoff System - Description and Operation

A. General (See Figures 27-13 & 27-14)

(1) The aileron hydraulic power shutoff system controls the supply of hydraulic pressure from the main hydraulic power system to the aileron hydraulic components. The system consists of a hydraulic power shutoff valve, located in the left landing gear wheel well, a 2-way cable system, and a control lever on the system engineer's control pedestal. The control lever is attached to a drum in the control pedestal. The cable system is routed from the drum, through the fuselage, to a sector in the wheel well. A pushrod and operating lever connect the sector to a yoke on the shutoff valve.

(2) The aileron hydraulic power shutoff valve consists of a filter, an automatic slide valve, manual slide valve and piston, and a bypass valve, all enclosed in a common housing. Internal passages connect the filter and valves hydraulically within the housing. Pressure inlet and return ports are connected by hydraulic lines to the main hydraulic power system. Hydraulic lines connect the pressure outlet ports to


ON
OFF
AILERON POWER SHUTOFF VALVE CONTROL LEVER
CONTROL ROD
VALVE YOKE
SYSTEM ENGINEER'S CONTROL PEDESTAL
A
AILERON HYDRAULIC POWER SHUTOFF VALVE (LOCATED IN LEFT MAIN WHEEL WELL)
AILERON HYDRAULIC POWER SHUTOFF SYSTEM CABLES
ON
OFF
DETENTED TO MANUAL POSITION (SYS PRESS ON)
TO AILERON
LOW PRESSURE RETURN
POWER OFF
TO AILERON
PRESSURE
LOW PRESSURE RETURN
MANUAL SLIDE VALVE
DETENTED TO POWER POSITION (SYS PRESS ON)
TO AILERON
LOW PRESSURE RETURN
POWER ON
TO AILERON
AUTOMATIC SLIDE VALVE
FILTER
PRESSURE
LOW PRESSURE RETURN

AILERON POWER CONTROL VALVE

Figure 27-13

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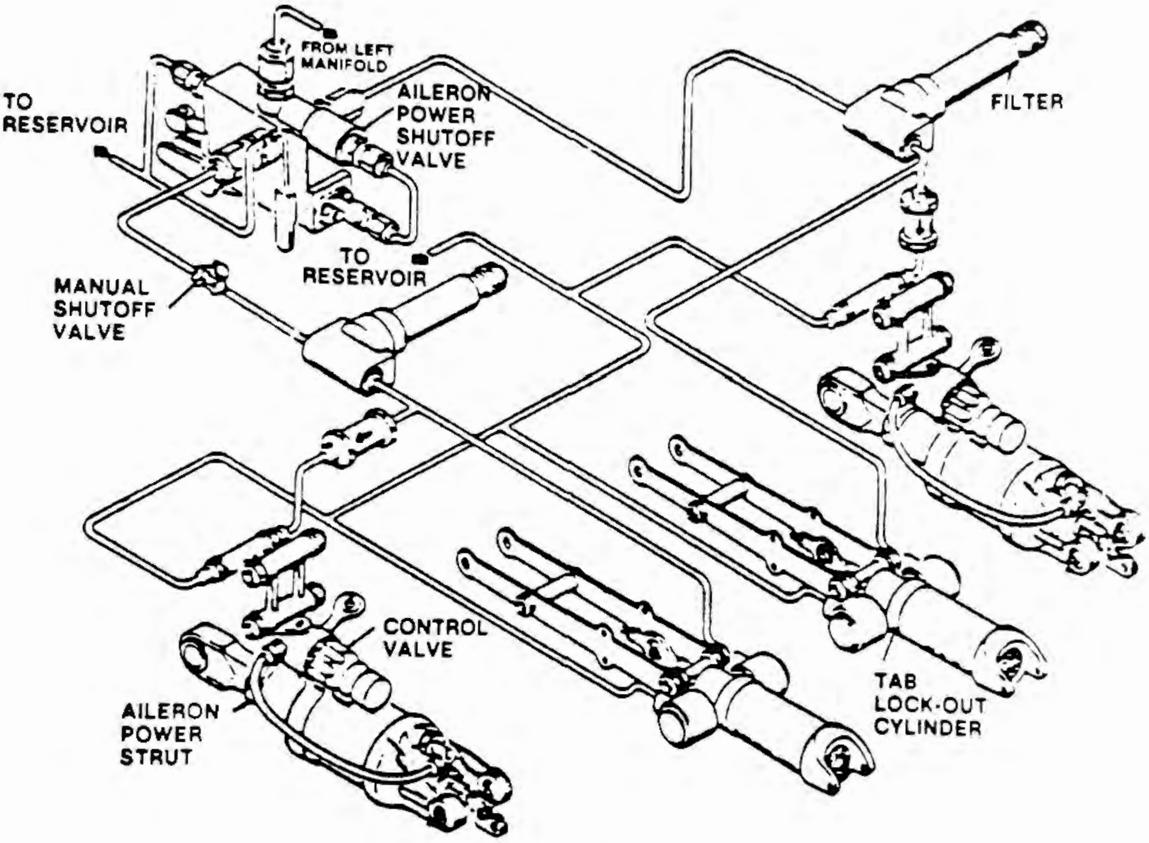


AILERON HYDRAULIC SYSTEM

FTX80230

Figure 27-14

5. Aileron Trim Control System - Description and Operation

A. General (See Figure 27-15)

(1) The aileron trim control system is a mechanical system which changes the neutral position of the aileron load-feel mechanism and moves the aileron trim tabs to provide lateral trim.

(2) The system consists of the aileron trim control knob and mechanism, two trim tabs, two trim tabs actuators, two aileron load-feel mechanisms, and connecting cable systems. The control knob is located on the aft end of a shaft in the pilot's control pedestal. A drum on the forward end of the shaft is connected by a two-way cable system to a drum on the upper end of a torque tube located in the right landing gear wheel well. Drum on the lower end of the torque tube are connected by two-way cable systems to the left and right aileron load-feel actuator screws. These latter cable systems incorporate a bridle cable system that is connected to the aileron trim tab actuators.

B. Component Description

(1) Aileron Trim Tabs

(a) There are two aileron trim tabs, one attached to the trailing edge of each inboard aileron, inboard of the control tabs. Trim tab travel is 22 1/2 degrees up and 14 1/2 degrees down from the faired position.

(b) Each trim tab is connected by mechanical linkage to trim tab actuator. Trim tabs are interchangeable without rebalancing the aileron.

drops below approximately 1150 psi, or if the rudder hyraulic power shutoff valve control lever is moved to the off position, hydraulic power is cut off and a power-to-manual reversion mechanism unlocks the rudder tab. Rudder pedal movement is then transmitted through the cable systems, the reversion mechanism, and mechanical linkage to move the rudder tab. Aerodynamic forces on the tab cause the rudder to move. A pressure reducer valve in the rudder hydraulic system and rudder travel limit stops are connected mechanically to the flap bus system so that hydraulic pressure is reduced and rudder travel is restricted when the flaps are not extended beyond 10 degrees.

(3) The rudder hydraulic power shutoff system is a mechanical system which controls the supply of hydraulic pressure to the rudder control system hydraulic components. The system consists of a hydraulic power shutoff valve connected by a cable system to control lever in the flight compartment. The shutoff valve automatically shuts off hydraulic pressure to the rudder components when the hydraulic power system pressure drops below approximately 1150 psi. The system may get used to shift the rudder control system to manual operation by moving the control lever to the off position.

(4) The rudder trim control system is a mechanical system which changes the neutral position of the rudder load-feel mechanism. The load-feel mechanism is connected to the rudder drive sector. The cable drum on the opposite end of the mechanism is connected by a cable system to the rudder trim control knob in the flight compartment. Rotating the trim control knob causes the load-feel mechanism to assume a new neutral position, moving the drive sector and causing the rudder pedals to move from the neutral position. The trim control knob also positions a trim indicator pointer to show the amount to rudder trim.

(5) The rudder standby hydraulic power system provides emergncy hydraulic power to the rudder hydraulic components. In the event normal pressure is not supplied by the hydraulic power system, the standby system may be actuated by a switch on the standby rudder power panel in the flight compartment.

(2) Aileron Trim Control Knob and Indicator Mechanism (See Figure 27-16)

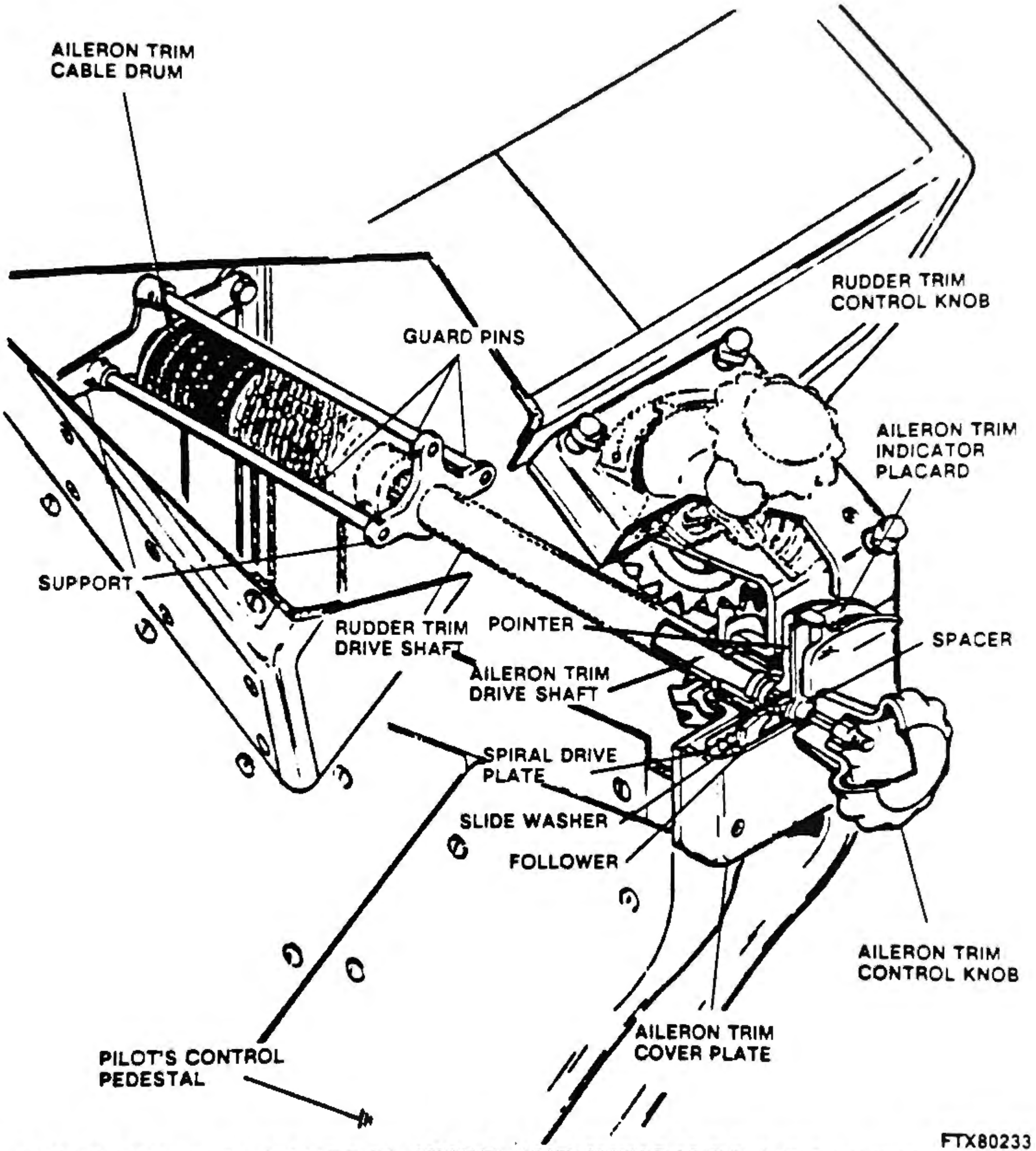
(a) The aileron trim control knob and indicator mechanism, located in the aft section of the pilot's control pedestal, provides a means of adjusting and indicating the amount of aileron trim. The aileron and rudder trim control mechanisms are combined in one unit.

(b) The aileron portion of the unit consists of a control knob, drive shaft, cable drum, and trim position indicator. The control knob is mounted on the aft end of the drive shaft, which is located inside the hollow rudder trim drive shaft. The cable drum is installed between two supports on the forward end of the drive shaft. The trim cable system is routed around the drum and through the fight compartment floor below the pedestal. Guard pins attached to the two supports prevent the cable from leaving the drum.

(c) The trim position indicator consists of a spiral drive plate, slide washer, follower, bushing, pointer, cover plate, and placard. The drive plate fits on the square end of the drive shaft, forward of the control knob. The bushing is located on the drive shaft on top of the drive plate. The slide washer, follower, and pointer are installed on the bushing. The placard is attached to the cover plate which is installed on the pedestal frame between the pointer and the control knob. A rig neutral notch on the cover plate provides a neutral position for rigging purposes. Since there may be a difference between the rigged neutral position and flight neutral position, the placard is adjustable so that it may be aligned with the pointer for the flight neutral position.

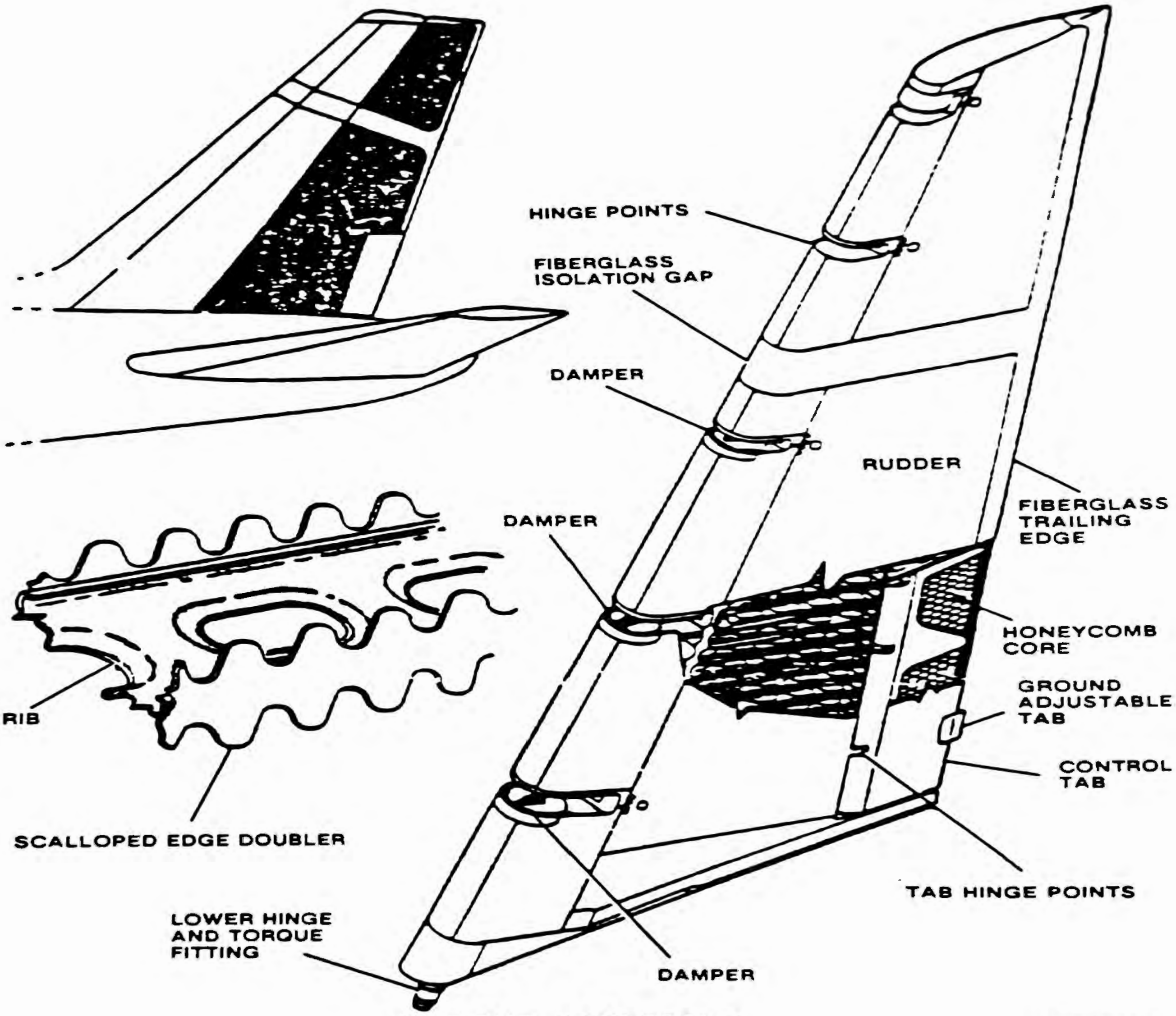
(3) Aileron Trim and Load-Feel Mechanism

(a) The aileron trim and load-feel mechanisms provide a simulated feel of flight load at the aileron control wheels to prevent overcontrol during power operation of the aileron control system. The mechanisms also act as centering devices to return the drive sectors and control wheels to an adjustable neutral position to obtain aileron trim.



AILERON TRIM CONTROL KNOB AND INDICATOR MECHANISM

Figure 27-16



RUDDER ASSEMBLY
Figure 27-18

(b) Each mechanism consists of a sector crank, load-feel crank, two load-feel arms, and a spring attach arm, all located on the aileron drive sector shaft and two load-feel springs, and a trim jackscrew. The load-feel arms are located on the sector shaft between the sector crank and the load-feel crank. Stops on the load-feel arms are in contact with adjustable stops on the two cranks. The spring attach arm is installed on the shaft between the load-feel arms. A spring is connected from each load-feel arm to the spring attach arm. A clevis on the aft of the jackscrew is connected to the load-feel crank.

(c) The trim jackscrew consists of a housing, jackscrew, nut and a cable drum. The nut is fixed centrally within the housing. The jackscrew is threaded into the nut and extends through the aft end of the housing. The trim cable system is routed around the cable drum which is attached to the forward end of the housing. The trim jackscrew is attached to the wing rear spar by a single bolt through a bearing in the cable drum.

(4) Aileron Trim Tab Actuator

(a) An aileron trim tab actuator is located in each inboard aileron forward of the trim tab inboard hinge. Each actuator consists of a pushrod, turnbuckle, jackscrew, cable drum, spool, and bracket.

(b) The turnbuckle is threaded into the pushrod which is attached to a horn on the leading edge of the trim tab. A nut and lockwasher prevent rotation of the turnbuckle within the pushrod. The aft end of the jackscrew is threaded into the turnbuckle. The cable drum, fixed to the forward end of the jackscrew, rotates on a bolt in the bracket which is attached to the aileron structure. The spool acts as a spacer between the cable drum bearing and the bracket.

C. Operation

(1) Aileron trim is obtained by rotating the aileron trim control knob, located on the pilot's control pedestal. The knob rotates the drive shaft and cable drum in the pedestal to drive the aileron trim cable systems. The cable systems rotate the cable drums on the aileron trim and load-feel mechanisms, causing the jackscrews to move the load-

feel cranks to a new neutral position. The load-feel cranks move the aileron drive sectors, causing the aileron control system cables to rotate the aileron control wheels away from the neutral position. At the same time, the bridle cable system rotates the aileron trim tab actuator cable drums. The actuator jackscrews drive the pushrods to move the aileron trim tabs to the trimmed position. During power operation, the new neutral position of the load-feel mechanism causes the aileron hydraulic components to move the aileron up or down to the trimmed position. During manual operation, the aerodynamic forces on the displaced trim tab move the aileron to provide trim.

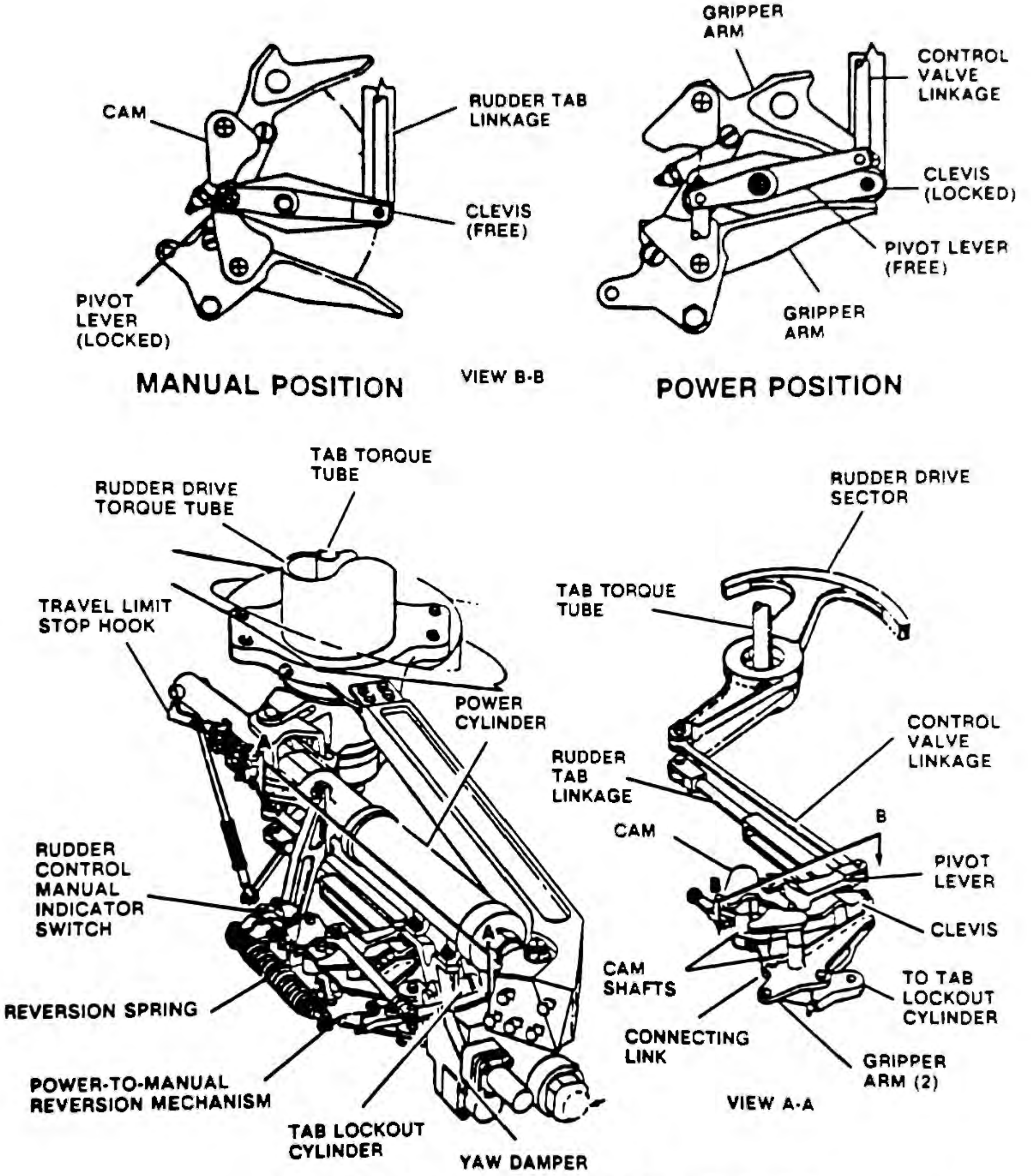
(2) When the aileron control wheels are in the neutral position, the stop pads on the load-feel arms are in contact with the stops on the sector crank and the load-feel crank. When the control wheels are rotated, the sector crank moves one of the load-feel arms while the other arm is held in position by the load-feel spring. The stops on the sector and load-feel cranks are adjusted so that a force of approximately 5 pounds is required at the stops to start the load-feel arm moving against the spring tension. This provides a simulated load-feel at the aileron control wheels. When the force is removed from the control wheels, the springs return the drive sector and control wheels to the neutral position.

6. Rudder and Tab - Description and Operation

A. General

(1) The rudder and tab are movable control surfaces which provide directional control of the airplane about the vertical axis. The movement of the rudder and tab is controlled by three subsystems: the rudder control system, the rudder hydraulic power shutoff system, and the rudder trim control system. A fourth subsystem, the rudder standby hydraulic power system, provides emergency hydraulic power to the rudder hydraulic components in the event of hydraulic power system failure.

(2) The rudder control system is a hydraulically actuated, mechanically controlled system which controls the rudder or tab from the rudder pedals in the flight compartment. During normal operation, the rudder tab is faired with the rudder and hydraulically locked in position. Rudder pedal movement is transmitted by cable systems to the hydraulic components which actuate the rudder. If hydraulic pressure



RUDDER HYDRAULIC POWER PACKAGE

FTX80236

Figure 27-19

7. Rudder Control System - Description and Operation

A. General (See Figure 27-17)

(1) The rudder control system controls the movement of the rudder hydraulically during power operation and the movement of the rudder tab mechanically during manual operation. The system consists of the following major components:

Components	**Location**
Rudder and tab	Attached to vertical stabilizer rear spar
Rudder drive and tab torque tubes	In aft fuselage section below rudder hinge line
Rudder pedals	Two sets in flight compartment
Rudder hydraulic power package	In aft fuselage section, adjacent to rudder drive torque tube
Rudder drive sector	In aft fuselage section, mounted on rudder tab torque tube
Hydraulic pressure reducer valve	In aft fuselage section, between rudder hydraulic power shutoff valve and hydraulic power package
Hydraulic filter	In aft fuselage, aft of pressure dome

(2) The rudder drive torque tube is attached to the base of the rudder at the hinge line. The tab torque tube is bearing mounted within the drive torque tube. A crank on the upper end of the tab torque tube is connected by pushrods to the rudder tab. Mechanical linkage also connects the lower end of the tab torque tube and rudder drive torque tube to the hydraulic power package. The drive sector, mounted on a bearing on the lower end of the tab torque tube, is connected by mechanical linkage to the power-to-manual reversion mechanism on the hydraulic power package. A two-way cable system connects the drive sector to the rudder pedals.

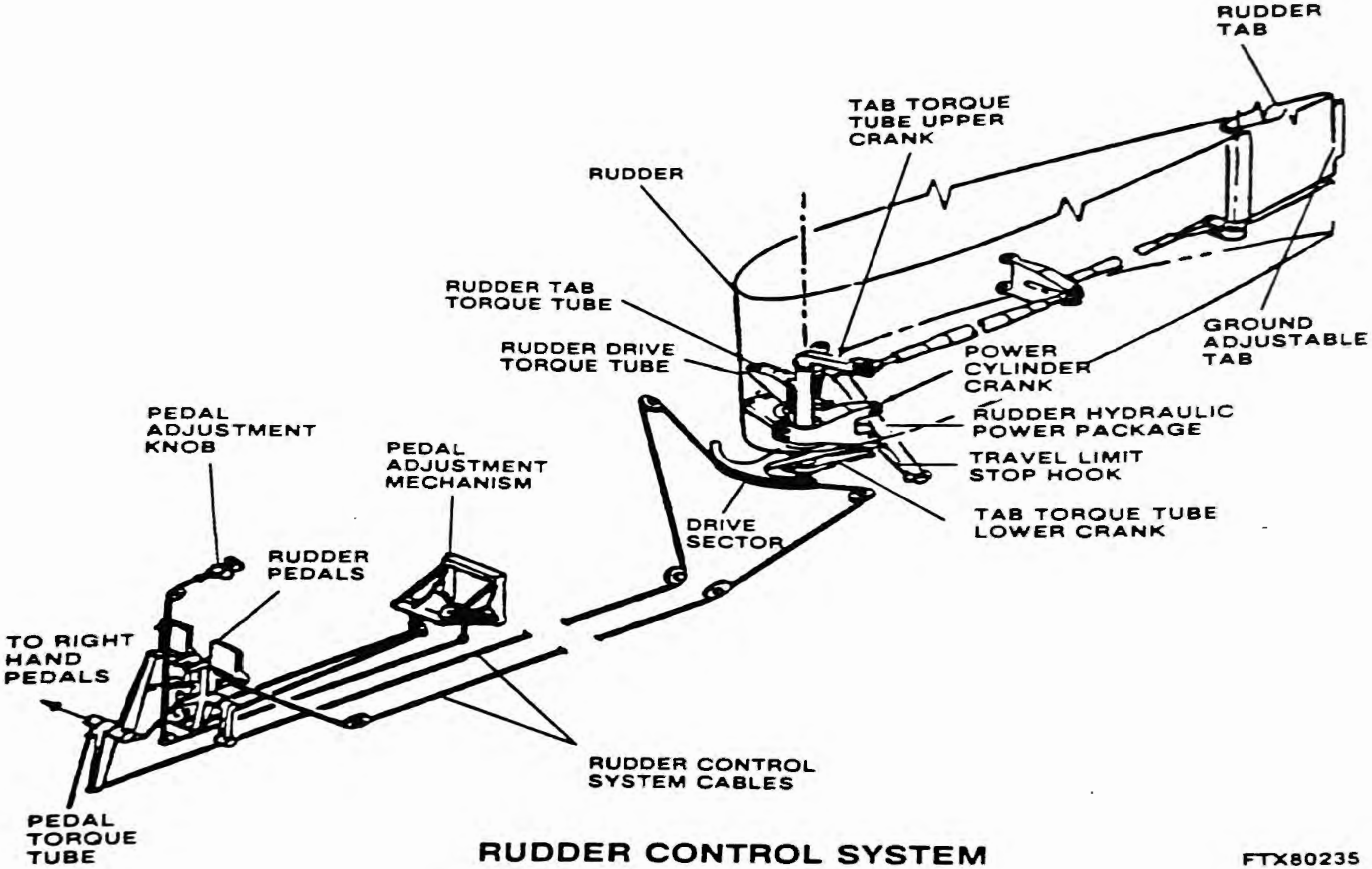

RUDDER TAB
TAB TORQUE TUBE UPPER CRANK
RUDDER
RUDDER TAB TORQUE TUBE
RUDDER DRIVE TORQUE TUBE
GROUND ADJUSTABLE TAB
POWER CYLINDER CRANK
PEDAL ADJUSTMENT KNOB
RUDDER HYDRAULIC POWER PACKAGE
PEDAL ADJUSTMENT MECHANISM
TRAVEL LIMIT STOP HOOK
TAB TORQUE TUBE LOWER CRANK
DRIVE SECTOR
RUDDER PEDALS
TO RIGHT HAND PEDALS
RUDDER CONTROL SYSTEM CABLES
PEDAL TORQUE TUBE
RUDDER CONTROL SYSTEM
FTX80235

Figure 27-17

B. Component Description

(1) Rudder and Tab (See Figure 27-18)

(a) The rudder is hinged to brackets on the vertical stabilizer trailing edge at five points. Rudder travel is approximately 32 1/2 degrees left or right of the neutral position. The rudder is aerodynamically balanced. Mass balance weights are installed in the leading edge for prevention of flutter.

(b) The rudder tab is hinged to the rear spar of the rudder at three points. Tab travel is approximately 21 1/2 degrees left or right of neutral position. A ground adjustable trim tab is incorporated in the tab trailing edge. Mass balance weights are installed in the tab for prevention of flutter. Rudder tabs are interchangeable without rebalancing the rudder.

(2) Rudder Pedals

(a) There are two sets of rudder pedals in the flight compartment. Each set is connected by mechanical linkage to a torque tube, located below the flight compartment floor, so that both sets of pedals operate in unison.

(b) An adjustment mechanism located aft of each set of rudder pedals, is connected by mechanical linkage to the pedals and by cable to an adjustment knob mounted below the instrument panel. The adjustment mechanism moves the pedals approximately 2 1/2 inches forward or aft of the neutral position for pilots of different stature. Adjustable stops limit the travel of the pedals.

(3) Rudder Hydraulic Power Package (See Figure 27-19)

(a) The rudder hydraulic power package consists of a power cylinder, manifold assembly, and a power-to-manual reversion mechanism.

(b) The power cylinder housing is connected to a crank which is splined to the rudder drive torque tube. The cylinder piston extends through glands at each end of the housing. One end of the piston is attached to a fixed support on the empennage structure. A pin through the opposite end of the piston acts as a stop for a spring-loaded stop hook that limits rudder travel in relation to flap position.

(c) The manifold assembly consists of a tab lockout cylinder, control valve, yaw damper actuator, electro-hydraulic transfer valve, solenoid shutoff valve, and a yaw damper actuation position transducer. Internal passages within the manifold connect the various valves and the power cylinder hydraulically. The tab lockout cylinder piston is connected mechanically to one of the reversion mechanism gripper arms. Mechanical linkage conencts the control valve operating arm, through the reversion mechanism, to the rudder drive sector. The control valve slide is connecting by a summing linkage to the operating arm and to the yaw damper actuator slide. The transfer valve, shutoff valve, and transducer are connected electrically to the autopilot circuits. Hydraulic lines connect the manifold to the rudder hydraulic power shutoff and the rudder hydraulic pressure reducer valve.

(d) The power-to-manual reversion mechanism automatically shifts the rudder control system from power to manual operation when the hydraulic pressure is shut off from the tab lockout cylinder. The reversion mechanism, mounted on the power cylinder, consists of two gripper arms, connecting link, two camshafts, pivot lever, clevis, reversion spring, and connecting linkage. The camshafts are installed on a support attached to the power cylinder. The gripper arms are installed on the camshafts and are connected together at one end by the connecting link. The clevis is installed on the support between the gripper arms and is connected by mechanical linkage to the rudder drive sector and the tab torque tube. The pivot lever is installed on the clevis and is connected by pushrod to the drive sector and the control valve operating arm. The reversion spring is connected between one of the gripper arms and a bracket on the support. The same gripper arm is conencted to the tab lockout cylinder piston.

(4) Rudder Hydraulic Pressure Reducer Valve (See Figure 27-20)

(a) The rudder hydraulic pressure reducer valve directs full hydraulic system pressure or reduced pressure to the rudder control valve, depending on the position of the flaps. The valve is located in the hydraulic system between the rudder hydraulic power shutoff valve and the control valve.

(b) The reducer valve consists of a mechanically controlled slide valve and a spring-loaded bypass valve. Internal passages within the housing connect the valves hydraulically. Pressure inlet and outlet ports are connected by hydraulic lines to the rudder hydraulic power shutoff valve, control valve, and system return lines. A crank, attached to the slide valve, is connected by mechanical linkage to the flap bus cable system.

C. Operation

(1) Hydraulic Power Operation (See Figure 27-21)

(a) The supply of hydraulic pressure to the rudder control system hydraulic components is controlleed by the rudder hydraulic power shutoff system. When the rudder hydraulic power shutoff valve control lever is moved to the on position, hydraulic pressure from the main hydraulic system or the rudder standby hydrualic system is directed to a pressure operated slide valve in the shutoff valve. When pressure reaches 1500 (±200) psi, the shutoff valve directs the pressure to the rudder pressure reducer valve, tab lockout cylinder, and the solenoid shutoff valve.

(b) The tab lockout cylinder piston in maintained in the extended position by the reversion spring on the power-to-manual reversion mechanism. When hydraulic pressure is directed to the lockout cylinder, the piston retracts, overcoming the reversion spring tension and closing the reversion mechanism gripper arms on a roller in the end of the clevis. This locks the clevis, and through the linkage to the tab torque tube, holds the rudder tab in faired position during power operation. At the same time, the reversion mechanism camshafts rotate and release a roller in the end of the pivot lever, allowing the lever to pivot freely. When the rudder pedals are operated, the cable system rotates the rudder drive

(3) If hydraulic pressure to the shutoff valve drops below 1150 (±50) when the control lever is in the on position, the manual slide valve spring unseats the valve, the automatic slide valve moves to the closed position, and pressure is bypassed to the system return lines. Hydraulic pressure is automatically shut off from the rudder components, and the rudder control system reverts to manual operation.

9. Rudder Trim Control System - Description and Operation

A. General

(1) The rudder trim control system is a mechanical system that changes the neutral position of the rudder trim and load-feel mechanism to provide rudder trim.

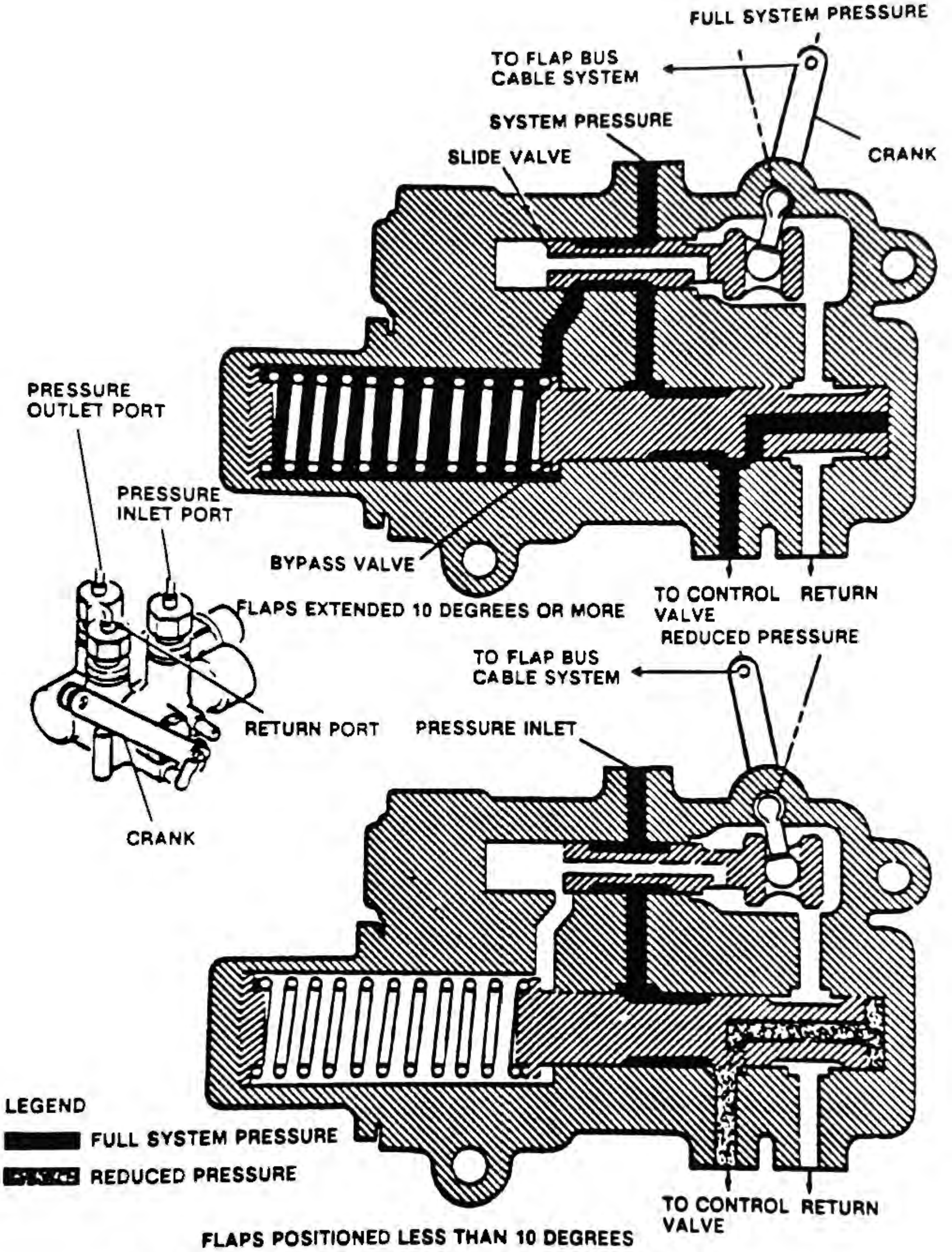
(2) The system consists of a trim control knob and indicator mechanism located in the aft section of the pilot's control pedestal, a 2-way cable system, and the rudder trim and load-feel mechanism. The trim control knob is connected by gears and shafts to a cable drum in the pedestal. The cable system is routed through the flight compartment floor and fuselage to a cable drum attached to the load-feel mechanism, which is located in the aft fuselage section. A shaft on the load-feel mechanism is connected to the rudder drive sector.

B. Component Description (See Figure 27-23)

(1) Rudder Trim Control Knob and Indicator Mechanism

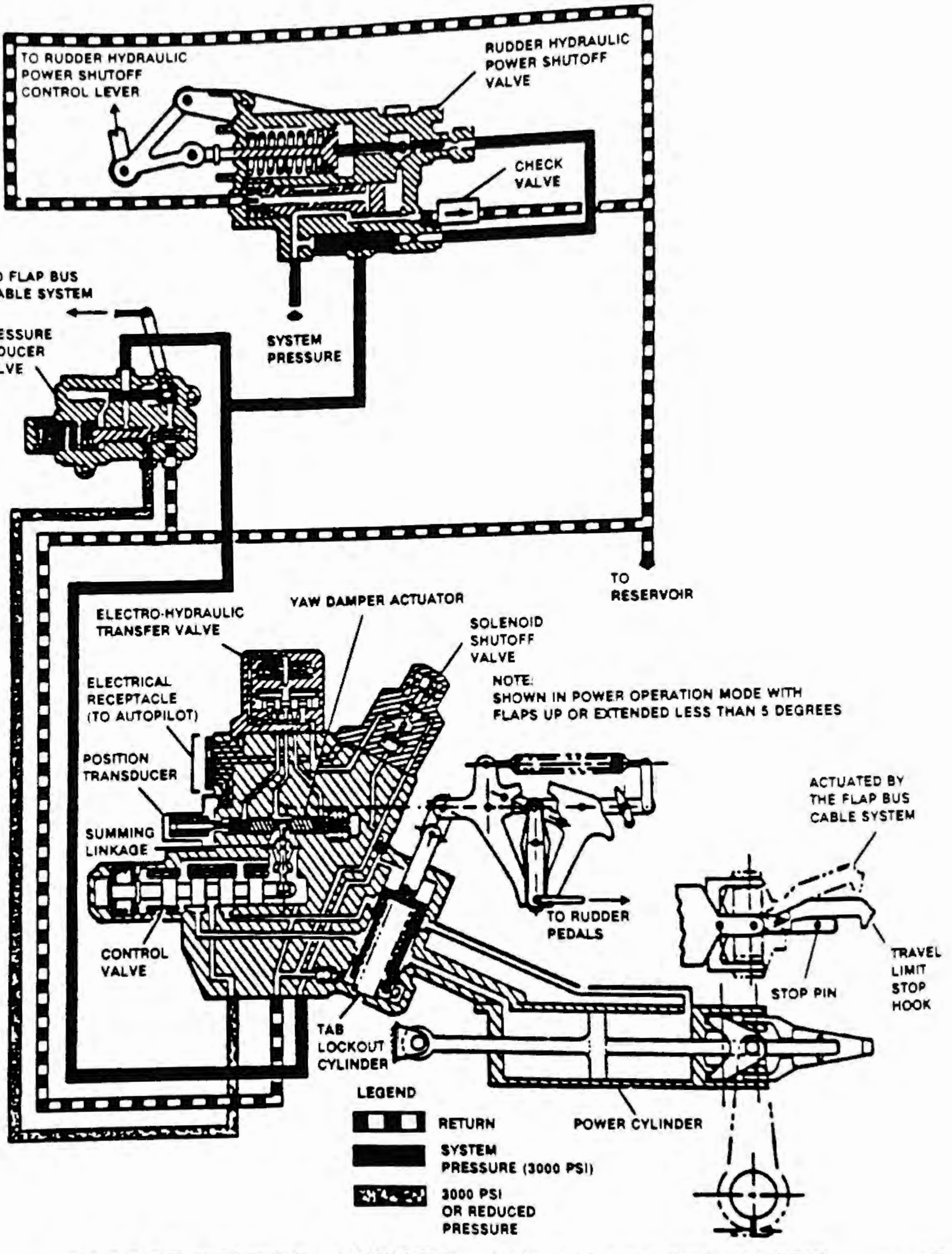
(a) Rudder trim control knob and indicator mechanism provides a means of adjusting and indicating the amount of rudder trim. The rudder and aileron trim control mechanisms are combined as one unit.

(b) The rudder portion of the mechanism consists of a cable drum, trim shaft, upper and lower bevel gears, drive shaft, trim position indicator, and control knob. The cable drum is attached to the forward end of the trim shaft. The lower bevel gear, located on the aft end of the trim shaft, meshes with the upper bevel gear which is attached to the lower end of the drive shaft. The trim position indicator and control knob are mounted on the upper end of the drive shaft.



RUDDER HYDRAULIC PRESSURE REDUCER VALVE FTX80237

Figure 27-20



NOTE:
SHOWN IN POWER OPERATION MODE WITH FLAPS UP OR EXTENDED LESS THAN 5 DEGREES

RUDDER CONTROL SYSTEM -- HYDRAULIC SCHEMATIC FTX80238

Figure 27-21

sector, causing mechanical linkage to move the pivot lever and actuate the control valve. Hydraulic pressure from the pressure reducer valve is directed by the control valve to the power cylinder. The power cylinder moves along its piston to rotate the rudder drive torque tube and drive the rudder to the left or right of neutral position as selected by rudder pedal movement.

(c) The distance that the power cylinder travels along the piston depends on the position of the spring-loaded stop hook attached to the cylinder. The stop hook and the pressure reducer valve operating crank are controlled by cables attached to the flap bus cable system. When the flaps are positioned at less than 5 degrees of extension, the spring maintains the stop hook in position so that a stop pin on the power cylinder piston is engaged by the hook, limiting rudder travel to approximately 10 degrees left or right of neutral position. At the same time, the pressure reducer valve reduces the hydraulic pressure supplied to the control valve to approximately 875 psi. When the flaps are extended more than 5 degrees, a cable pulls the stop hook clear of the power cylinder stop pin, allowing the cylinder to move the rudder to the maximum travel of approximately 32 1/2 degrees left or right of neutral position. At the same time, the cable system operates the pressure reducer valve, which then allows full system pressure to the control valve.

(d) The solenoid shutoff valve and the electro-hydraulic transfer valve are actuated by electrical input from the autopilot. When the solenoid in the shutoff valve is not energized, hydraulic pressure is shut off from the transfer valve and ported to the system return line. When the solenoid is energized, pressure is directed through the shutoff valve to the transfer valve. With no electrical input at the transfer valve coil, the pressure is ported through the yaw damper actuator and control valve return passages to the system return line. On receipt of an electrical input, the transfer valve directs pressure to either the rudder left or rudder right side of the yaw damper actuator. The yaw damper actuator moves a summing linkage which in turn moves the control valve arm, causing the control valve to direct hydraulic pressure to the power cylinder. Input from the rudder pedals and yaw damper input is mechanically summed by the summing linkage. The position transducer, connected mechanically to the yaw damper actuator, generates an electrical signal proportional to the displacement of the yaw damper actuator from the null position. This signal is then transmitted to the autopilot yaw computer.

(2) Manual Operation

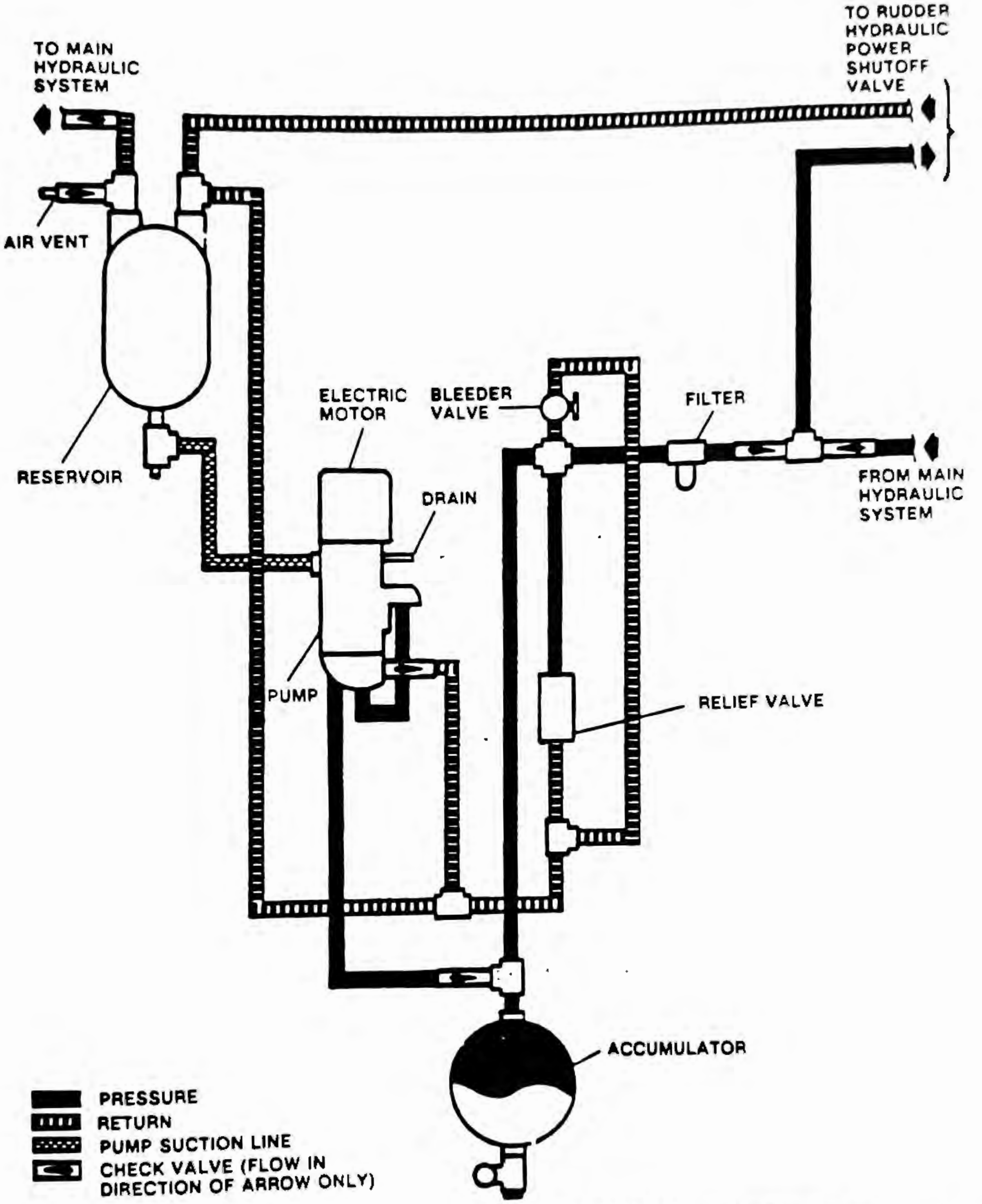
(a) If hydraulic pressure to the rudder hydraulic power shutoff valve drops below 1150 (±50) psi, the shutoff valve closes and hydraulic fluid is bypassed to the system return line. Hydraulic pressure to the tab lockout cylinder is cut off, allowing the reversion spring to extend the lockout cylinder piston. The reversion mechanism gripper arms open to free the clevis and permit movement of the rudder tab linkage, unlocking the tab from the faired position. At the same time, the camshafts rotate to close the cams around the roller in the end of the pivot lever, preventing movement of the control valve linkage. When the rudder pedals are operated, the rudder drive sector linkage moves the clevis. Mechanical linkage from the clevis rotates the rudder tab torque tube to drive the tab left or right of the faired position. Aerodynamic forces on the tab moves the rudder. Manual operation may also be selected by moving the rudder hydraulic power shutoff valve control lever to the off position.

(b) A switch on the hydraulic power package is actuated whenever the rudder control system reverts to manual mode of operation and a rudder control manual light comes on in the flight compartment. During manual operation, hydraulic fluid is bypassed from one side of the power cylinder piston to the other, allowing the cylinder to move freely along the piston.

8. Rudder Hydraulic Power Shutoff System - Description and Operation

A. General (See Figure 27-22)

(1) The rudder hydraulic power shutoff system controls the supply the hydraulic pressure form the main hydraulic power system or the rudder standby hydraulic system to the rudder control system hydraulic components. The system consists of a hydraulic power shutoff valve, located in the aft fuselage section, a 2-way cable system and a control lever on the systems engineer's control pedestal. The control lever is attached to a drum in the pedestal. The cable system is routed



RUDDER STANDBY HYDRAULIC SYSTEM -- SCHEMATIC FTX8024

Figure 27-24

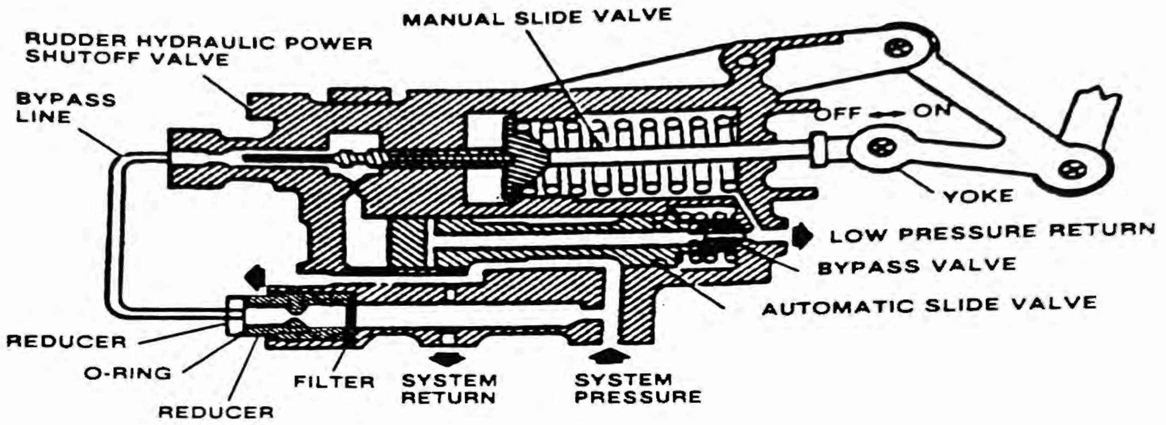
from the drum, through the flight compartment floor, and through the fuselage to a sector in the aft fuselage section. A pushrod and operating lever connect the sector to a yoke on the shutoff valve.

(2) The rudder hydraulic power shutoff valve consists of a filter, an automatic slide valve, manual slide valve and piston, and a bypass valve, all enclosed in a common housing. Internal passages connect the filter and valve hydraulically within the housing. Pressure inlet and return ports are connected by hydraulic lines to the main hydraulic power system and the rudder standby hydraulic system. Hydraulic lines connect the pressure outlets to the rudder pressure reducer valve and to the rudder tab lockout cylinder. The yoke on the exposed end of the manual slide valve piston is connected by mechanical linkage to the cable system.

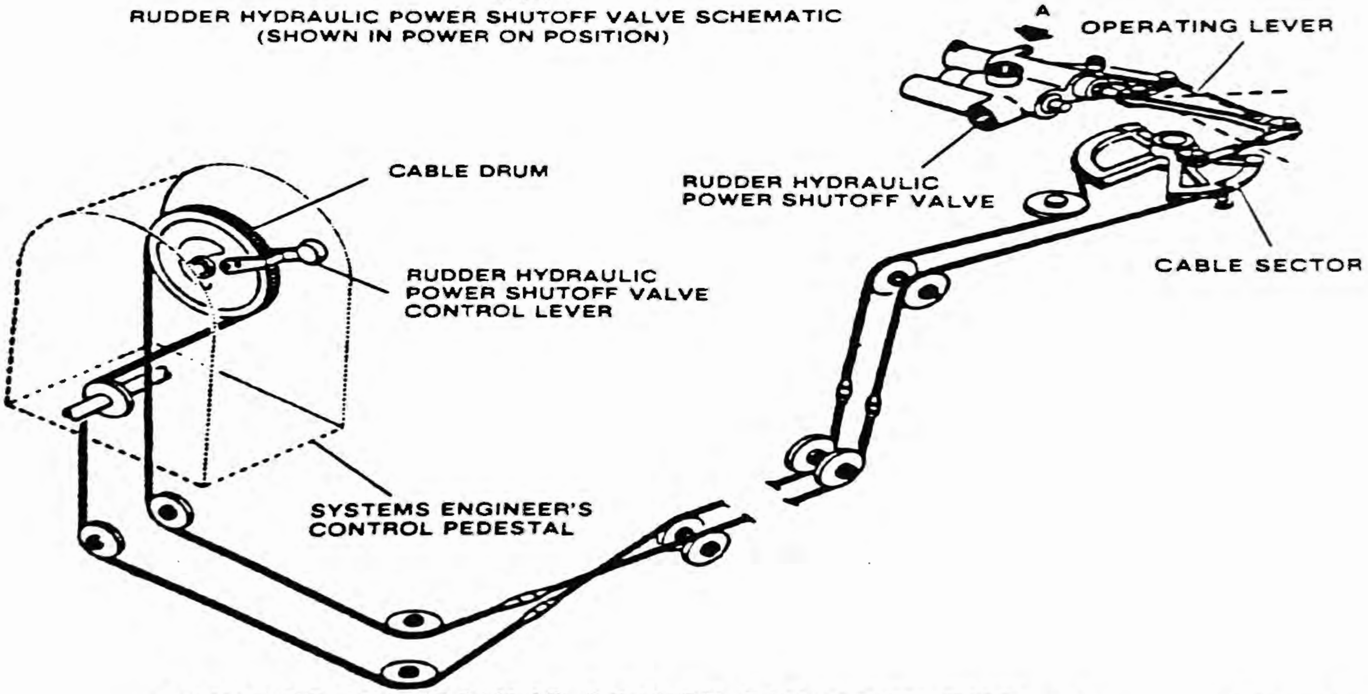
B. Operation

(1) Hydraulic pressure from the main hydraulic system or the rudder standby hydraulic system is supplied through the shutoff valve filter to the manual slide valve and the automatic slide valve. If the rudder hydraulic power shutoff valve control lever is moved to the off position, the cable system and mechanical linkage pushes the manual slide valve piston, unseating the valve and allowing pressure to be bypassed to the system return lines. This reduces the pressure behind the automatic slide valve piston, allowing the spring-loaded slide to close. Hydraulic pressure is shut off from the rudder hydraulic components, and the rudder control system reverts to manual operation.

(2) When the rudder hydraulic power shutoff valve control lever is moved to the on position, the cable system and mechanical linkage pull the manual slide valve piston away from the valve. When hydraulic pressure is sufficient to overcome the manual slide valve spring, the valve is reseated and pressure is directed to the automatic slide valve. The automatic slide valve spring is overcome and the slide is moved to open passages to the outlet port that supplies the rudder components. This shifts the rudder control system to power operation. The shutoff valve is preset so that a pressure of 1500 (±200) psi is required to open the valve to the rudder components.



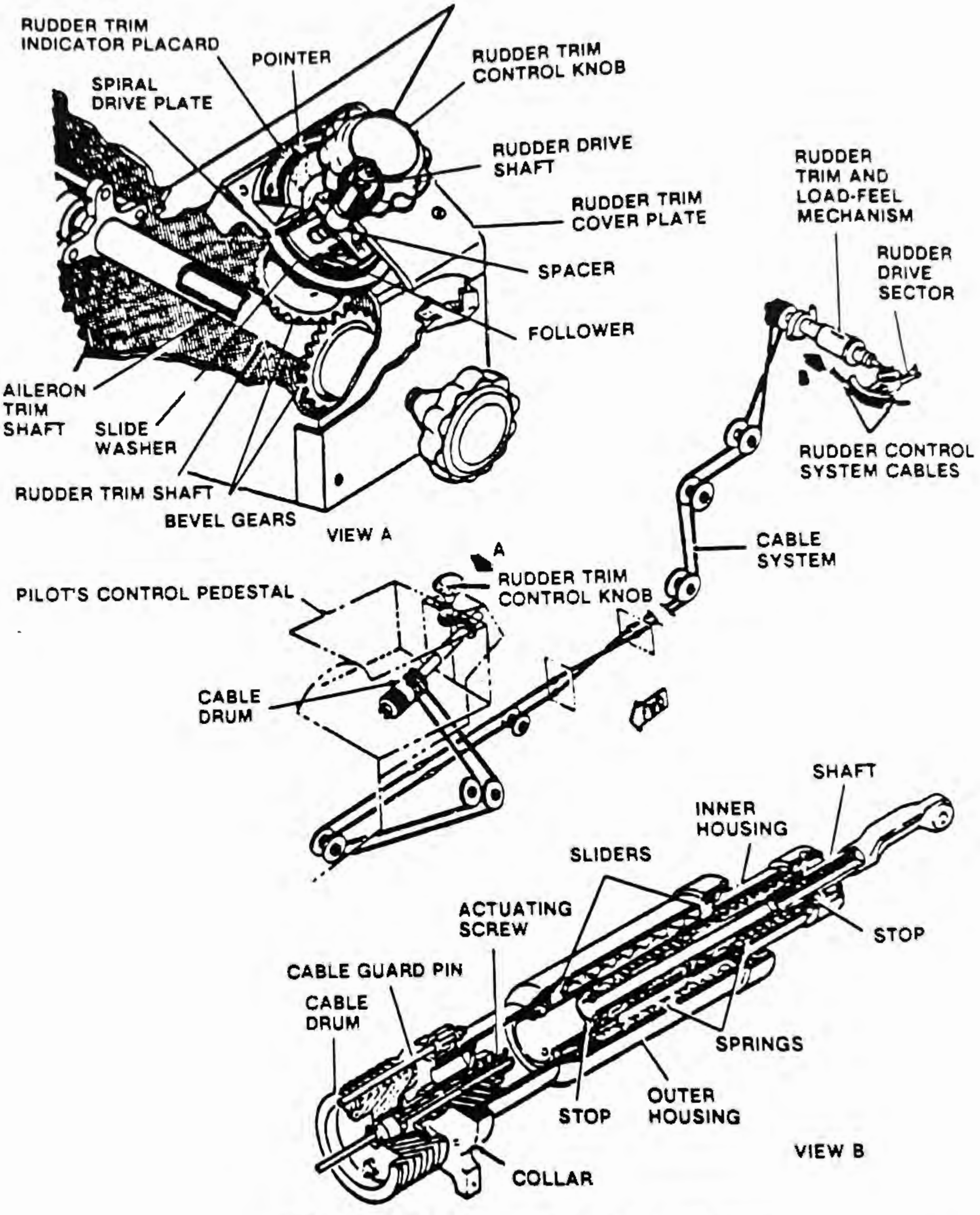
VIEW A
RUDDER HYDRAULIC POWER SHUTOFF VALVE SCHEMATIC
(SHOWN IN POWER ON POSITION)


A
OPERATING LEVER
CABLE DRUM
RUDDER HYDRAULIC POWER SHUTOFF VALVE
CABLE SECTOR
RUDDER HYDRAULIC POWER SHUTOFF VALVE CONTROL LEVER
SYSTEMS ENGINEER'S CONTROL PEDESTAL

RUDDER HYDRAULIC POWER SHUTOFF SYSTEM

FTX80239

Figure 27-22



RUDDER TRIM CONTROL SYSTEM

FTX80240

Figure 27-23

(c) The trim position indicator consists of a spiral drive plate, slide washer, follower, pointer, bushing, placard, and cover plate. The spiral drive plate fits on the square end of the drive shaft, below the control knob. The slide washer, follower, and pointer are installed on the bushing which is located on the drive shaft immediately on top of the drive plate. The placard is attached to the cover plate which is installed on the pedestal frame between the pointer and control knob. A rig neutral notch on the cover plate provides a neutral position for rigging purposes. Since there may be a difference between rigged neutral position and flight neutral position, the placard is adjustable so that it may be aligned with the pointer for flight neutral position.

(2) Rudder Trim and Load-Feel Mechanism

(a) The rudder trim and load-feel mechansim serves as an adjustable neutral point to obtain rudder trim and provides a simulated feel of flight load at the rudder pedals. The mechanism also acts as a centering device to return the rudder controls to the neutral (or adjusted neutral) position when the rudder pedals are released.

(b) The mechanism consists of a shaft, inner housing, outer housing, sliders, two springs, a cable drum, actuating screw, collar, and internal stops. The shaft is installed in the inner housing and the small spring is held around the shaft by stops on the shaft and housing. The inner housing is centered within the outer housing by the sliders. The large spring is installed around the inner housing between the sliders. Stops on both ends of the shaft prevent overtravel of the shaft. The cable drum is attached to the actuating screw which is threaded through the collar around one end of the outer housing. The exposed end of the shaft is connected to the rudder drive sector. The cable drum is attached to a bracket which is mounted on a support attached to the structure. Linkage connecting the collar to the bracket prevents the collar from rotating around the housing. The trim control system cables are routed around the cable drum.

C. Operation

(1) Rudder trim is accomplished by rotating the rudder trim control knob. The drive shaft drives the bevel gears, causing the trim shaft to rotate the cable drum in the pedestal. The cable drum drives the cable system to rotate the cable drum on the trim and load-feel mechanism. This rotates the actuating screw, causing the load-feel mechanism to travel along the actuating screw to move the rudder drive sector and rudder pedals to a new neutral position. During power operation, the drive sector controls the hydraulic components which move the rudder to obtain trim. During manual operation the drive sector positions the rudder tab so that aerodynamic forces on the tab move the rudder to the trimmed position.

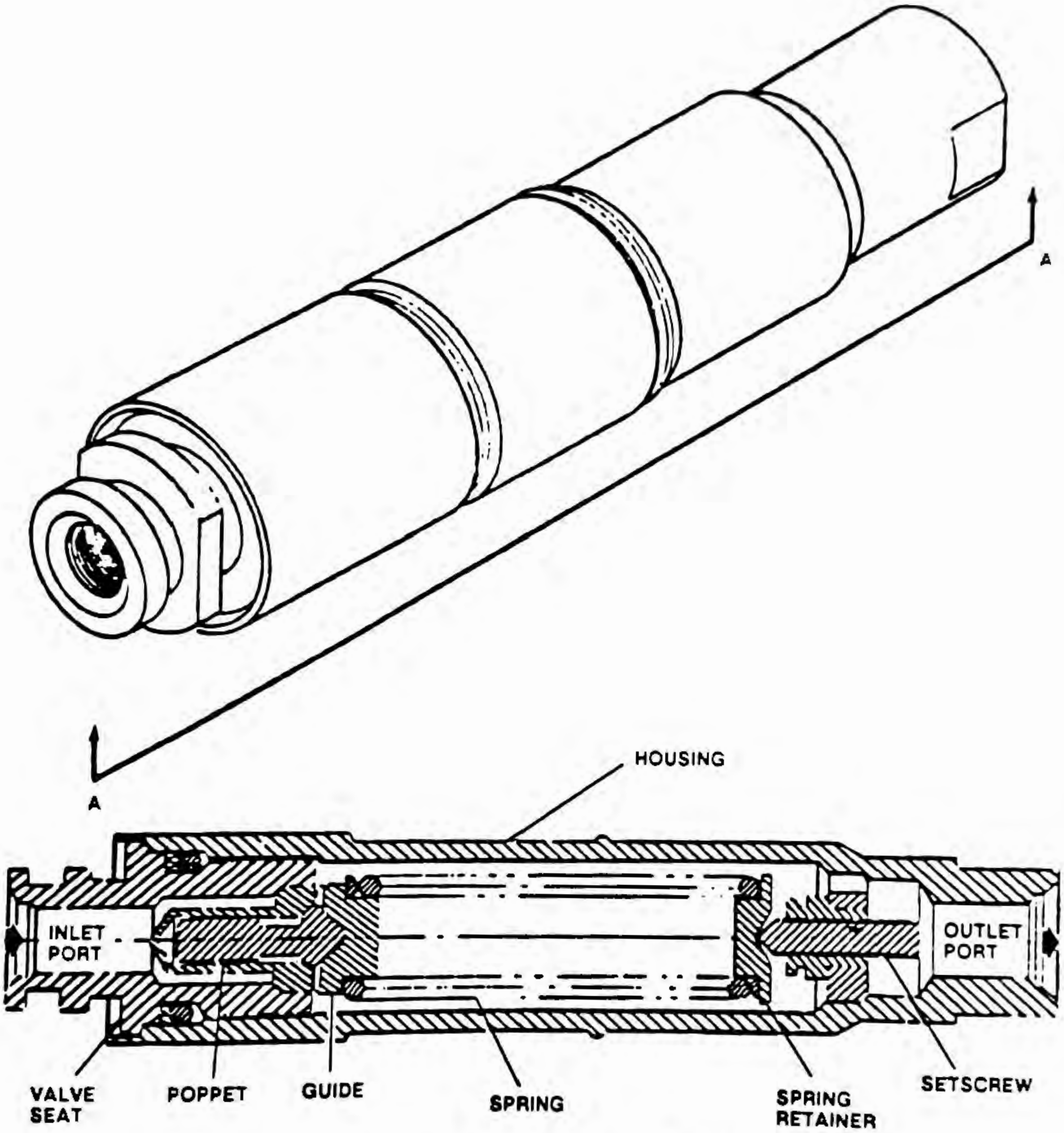
(2) When the rudder trim control knob is rotated, the spiral drive plate in the trim position indicator is rotated, moving the follower sideways. A pin on the follower moves the indicator pointer to indicate the amount of trim on the placard. Stops on the drive plate prevent overtravel of the trim control knob.

(3) When the rudder pedals are moved, the rudder drive sector moves the shaft in the load-feel mechanism. The stops on the shaft compresses the small spring against the stop on the inner housing. The force required to compress the small spring increases until it is greater than the force required to compress the large spring. At this point, the small spring moves the inner housing against the slider, compressing the large spring. The resistance position, providing the simulated load-feel at the rudder pedals. When force is removed from the pedals, the springs return to their extended positions, returning the drive sector and rudder pedals to the neutral position.

10. Rudder Standby Hydraulic System - Description and Operation

A. General (See Figure 27-24)

(1) The rudder standby hydraulic system is an auxiliary hydraulic system, connected to the main hydraulic power system, that provides an alternate source of hydraulic pressure for the rudder hydraulic components. In the event that normal pressure is not supplied by the main hydraulic power system, the standby system may be actuated by a switch in the flight compartment.



RUDDER STANDBY HYDRAULIC SYSTEM -- PRESSURE RELIEF VALVE

FTX80244

Figure 27-27

(2) The standby system consists of an auxiliary hydraulic pump, actuator switch, reservoir, accumulator, relief valve, filter, bleeder valve, check valves, and connecting lines and fittings.

B. Component Description

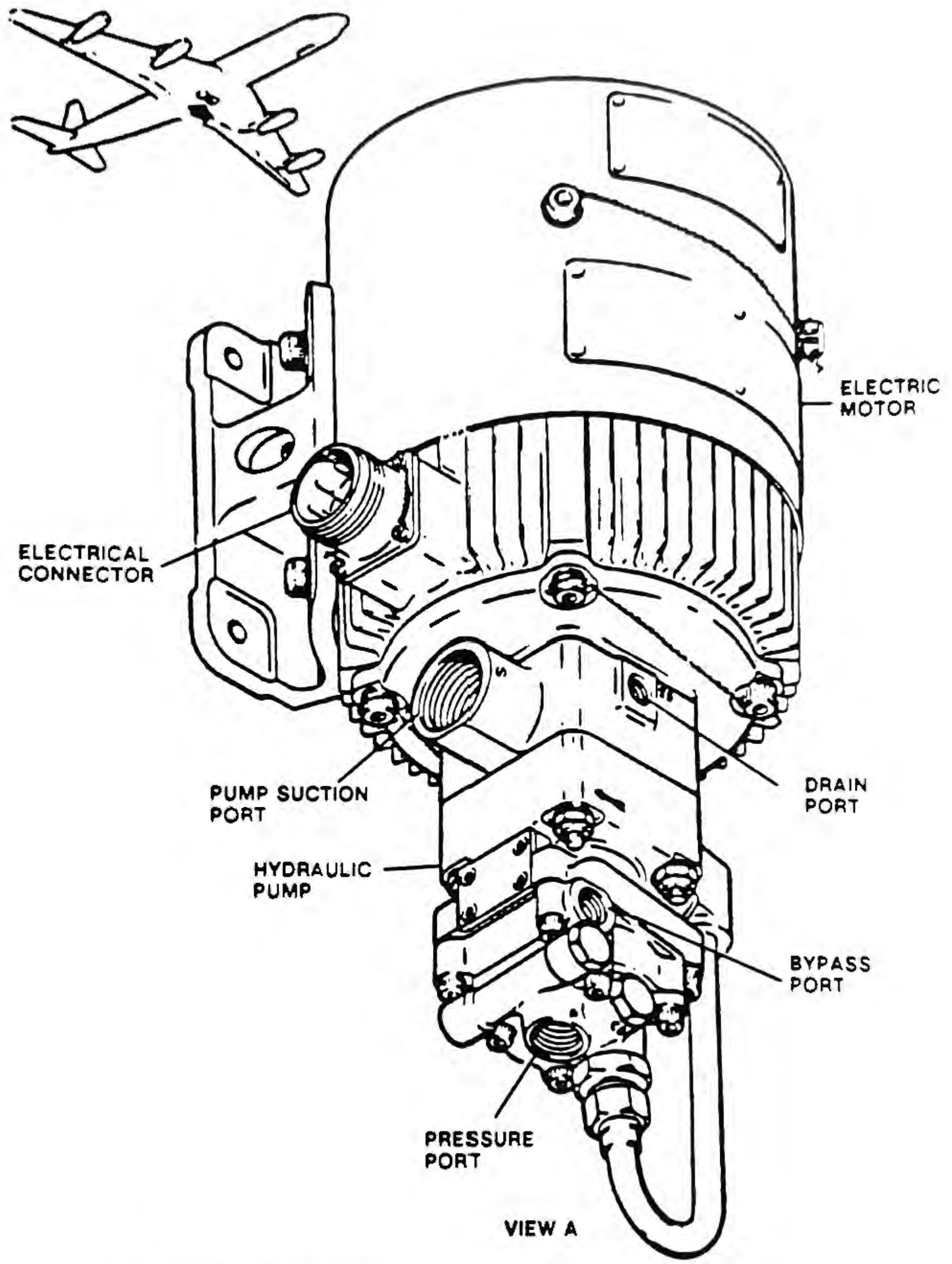
(1) Auxiliary Hydraulic Pump (See Figure 27-25)

(a) The auxiliary hydraulic pump, located in the left main gear wheel well, supplies hydraulic pressure for the rudder standby hydraulic system. The auxiliary hydraulic pump consists of an electric motor and a hydraulic pump.

(b) The electric motor is a 115/200-volt, 3-phase, 400-cps, continuous duty motor mounted directly on top of the hydraulic pump. The motor rotor has an internally splined output shaft which fits on the externally splined drive shaft of the pump. The motor is connected electrically to the standby rudder power switch located on the standby rudder power panel.

(c) The hydraulic pump is a variable displacement pump comprising of the following major parts: a four piece housing, cylinder and piston group, pivoting hanger with an inclined camface, hold down plate, pressure compensating valve, and bearings.

(d) When the electric motor is actuated, the drive shaft rotates the cylinder and piston group. Each revolution of the cylinder causes one complete stroke of each piston. The pistons are held against the camface of the hanger by the hold down plate, providing positive piston return. The displacement of fluid from the pump discharge port is controlled by the pressure compensating valve. The pump delivers full flow of 3.9 gpm at system pressures up to approximately 2700 psi. At this point, the compensating valve reduces flow until at approximately 3000 psi, displacement is decreased to zero.



RUDDER STANDBY HYDRAULIC SYSTEM -- AUXILIARY HYDRAULIC PUMP

FTX80242

Figure 27-25

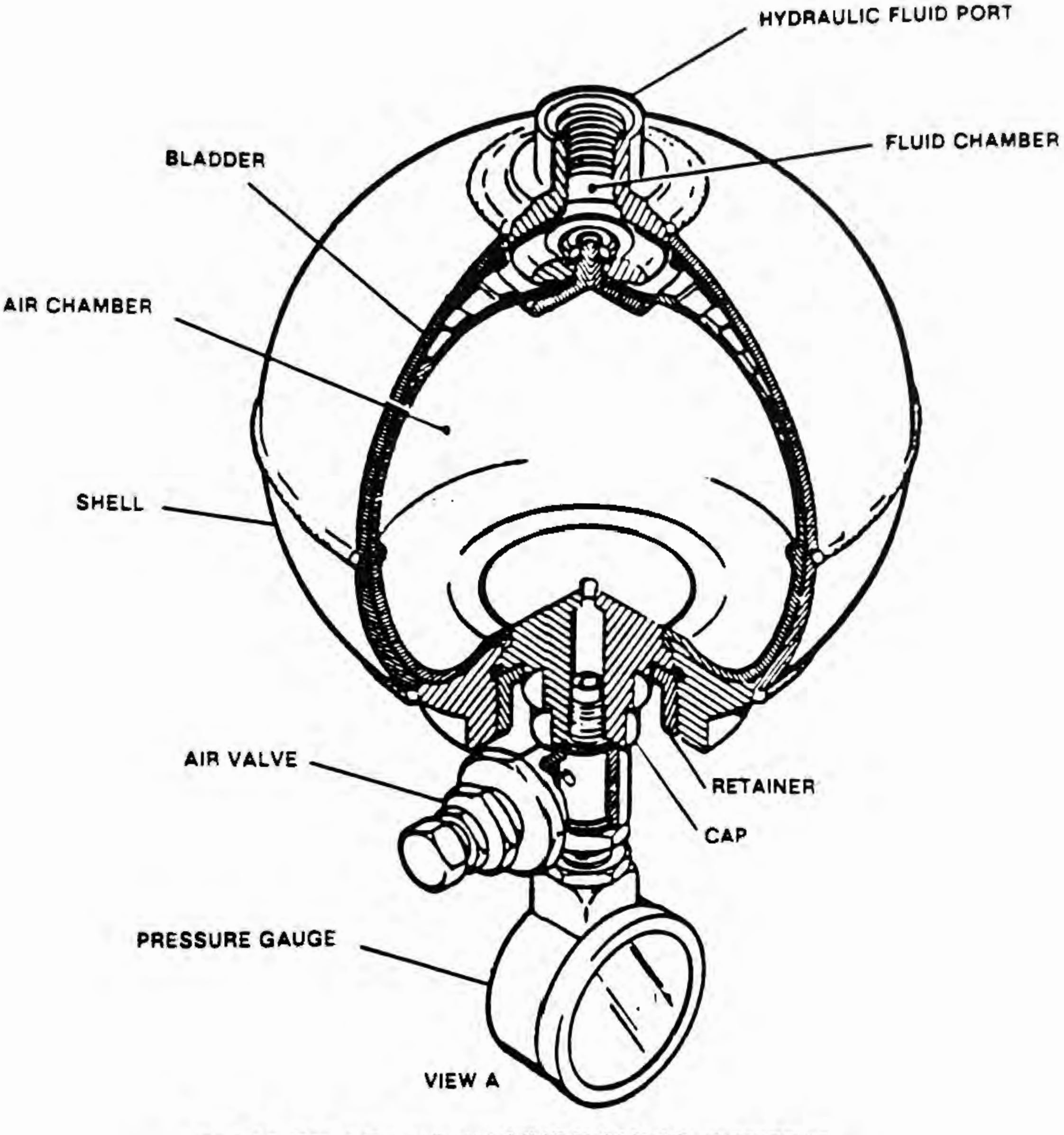
(2) Rudder Standby Hydraulic System Reservoir

(a) The reservoir, located in the left main gear wheel well, is a cylindrical tank that stores a supply of hydraulic fluid for use in the standby system. The reservoir has two ports on the upper end and one port on the lower end. A flexible suction line from the auxiliary hydraulic pump is connected to a manifold installed in the lower port. A magnetic drain plug is also installed in the manifold. The standby system return lines and the return line from the rudder hydraulic power shutoff valve are connected to a tee fitting in one of the upper ports. An air intake line with a vacuum check valve and the return line to the main hydraulic system are connected to a tee fitting in the other port. A visual fluid indicator is installed in the side of the reservoir.

(b) When the standby system is actuated, hydraulic fluid is drawn through the suction port at the base of the reservoir and supplied to the rudder hydraulic components. Fluid returning from the rudder components is directed back to the reservoir through one of the upper ports. The reservoir is also included in the main hydraulic system return line from the rudder and horizontal stabilizer hydraulic systems. A check valve in the main hydraulic system return line prevents back surges of fluid from re-entering the reservoir.

(3) Rudder Standby Hydraulic System Pressure Accumulator (See Figure 27-26)

(a) The pressure accumulator, located in the left main gear wheel well, absorbs surges of hydraulic pressure in the system caused by pressure fluctuations and provides supplementary pressure for the standby system for limited periods of peak demand.



RUDDER STANDBY HYDRAULIC SYSTEM -- PRESSURE ACCUMULATOR

FTX80243

Figure 27-26

(b) The accumulator is a spherical pressure chamber with a flexible inner bladder. The accumulator is equipped with an air valve and a direct-reading pressure gage connected to the base of the accumulator. The gage indicates the pressure within the accumulator. The bladder is inflated with dry compressed air, through the air valve, at a pressure lower than normal hydraulic system operating pressure. The outer chamber contains hydraulic fluid and is connected to the system pressure line. As hydraulic system pressure builds up, fluid enters the chamber; and the air within the bladder is further compressed. When pressure in the system drops below the pressure in the chamber, the compressed air in the bladder forces the fluid out of the accumulator.

(4) Hydraulic Pressure Relief Valve (See Figure 27-27)

(a) The pressure relief valve is located in the rudder standby hydraulic system downstream of the pump and pressure accumulator to prevent the system pressure from exceeding a safe limit.

(b) The pressure relief valve consists of a guide, poppet, valve seat, housing, spring, spring retainer, and setscrew. With normal system pressure, the spring tension against the guide holds the poppet seated in the valve seat, which is threaded into one end of the housing. The setscrew, which is threaded into a nut installed in the opposite end of the housing, is seated against the spring retainer. When system pressure reaches approximately 3300 psi, the spring tension is overcome, the poppet is unseated, and excessive pressure is directed through the valve to the system return line. Spring tension is set so that the poppet is reseated as pressure drops to a minimum of 3000 psi.

(5) Hydraulic Filter

(a) A 10-micron hydraulic line filter is installed in the rudder standby hydraulic system downstream of the pump and pressure accumulator.

(b) The filter consists of a housing, filter head, and a replaceable filter element. The filter head has two ports, one marked inlet and one marked outlet. A magnetic plug at the base of the housing may be removed for cleaning without loss of hydraulic pressure.

(6) Bleeder Valve

(a) A manually operated bleeder valve is installed in the rudder standby hydraulic system downstream of the pump and pressure accumulator. The valve allows system pressure to be bypassed back to the reservoir during maintenance so that the accumulator charge may be checked.

(7) Check Valves

(a) There are three 1-way check valves and a vacuum check valve included in the rudder standby hydraulic system. One check valve, located in the pressure line downstream of the filter, isolates the standby system from surges of pressure from the main hydraulic power system. The other two check valves, located in the system return lines, prevent back surges of pressure from entering the pump bypass port and the reservoir return port.

(b) The vacuum check valve, attached to the reservoir air vent, permits passage of ambient air pressure but prevents hydraulic fluid from leaving the reservoir through the air vent, thus assuring that reservoir pressure does not drop below atmospheric pressure.

11. Elevator and Tab - Description and Operation

A. General

(1) The elevator and tab system provides longitudinal control of the airplane about the lateral axis. The system consists of two subsystems: the elevator control system, and the pitch (Mach) trim compensator system.

(2) The elevator control system controls the movement of the elevator and tabs from the control columns in the flight compartment. The pitch (Mach) trim compensator system automatically applies compensating trim to the elevator control system to correct the pitching moment of the airplane at high airspeeds.

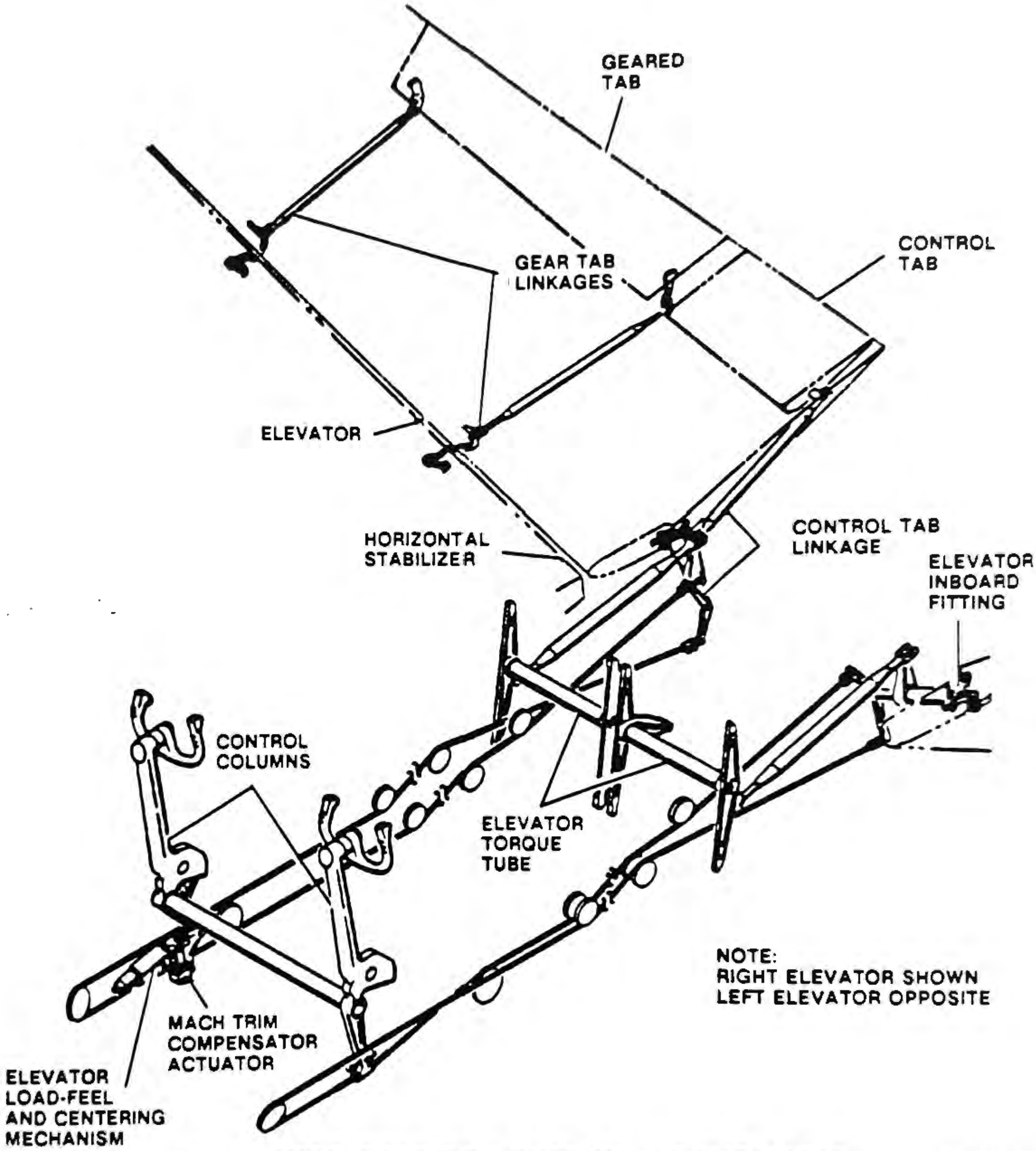
B. Elevator Control System (See Figure 27-28)

(1) The elevator control system is actuated mechanically and consists of the following major components: two elevators, two control tabs, two geared tabs, two control columns, a load-feel and centering mechanism, and two elevator dampers. The elevators are operated aerodynamically by the tabs. The control tabs are controlled mechanically by cable systems from the control columns. The geared tab on each elevator is linked mechanically to the horizontal stabilizer so that, as the elevator moves, the geared tab moves in the same direction as the control tab to provide additional aerodynamic control surface.

(2) A 2-way cable system, connected to the base of the left control column, is routed through the fuselage and tail section to a crank at the inboard end of the left elevator. The crank is mounted on a shaft installed through the elevator inboard hinge fiting. The opposite end of the shaft is connected by a pushrod to the elevator control tab. The elevator inboard hinge fitting is connected by a crank and pushrod to the elevator torque tube. The right elevator is connected by a similar mechanical system to the elevator torque tube and the right control column.

(3) Elevator and Tabs

(a) The elevators are hinged to brackets attached to the horizontal stabilizer rear spar. Elevator travel is approximately 27 degrees up and 16 1/2 degrees down from the neutral position. The elevators are interconnected by a torque tube so that they operate in unison. Both elevators are aerodynamically balanced and mass balance weights are installed in the leading edge sections to minimize flutter.



ELEVATOR CONTROL SYSTEM -- SCHEMATIC

FTX80245

Figure 27-28

(b) A control tab is hinged to the inboard trailing edge of each elevator. Control tab travel is approximately 8 1/2 degrees up and 26 1/2 degrees down from the neutral position. Fittings on the inboard end of each control tab are connected by mechanical linkage to the elevator control system cables. Control tabs are mass balanced to minimize flutter and are interchangeable without rebalancing the elevator.

(c) A geared tab is hinged to the trailing edge of each elevator, outboard of the control tab. Geared tabs are rigged to the neutral position, when the elevator is faired with the horizontal stabiizer and travel is approximately 4 3/4 degrees up and 26 3/4 degrees down from the neutral position. Two pushrods, one attached to a fitting at each end of the geared tab, are connected to fittings on the horizontal stabilizer. Geared tabs are interchangeable without rebalancing the elevator.

(4) Control Columns

(a) There are two control columns in the flight compartment. The columns, when moved forward or aft, drive the elevator control system cables to operate the control tabs. Aileron cables and electrical wires, from the aileron control wheel at the top of each control column, are routed through the columns.

(b) A control column torque tube, located below the flight compartment floor, interconnects the two control columns so that they operate in unison. The elevator cable systems are connected to an arm at the base of each control column. The load-feel and centering mechanism and the pitch (Mach) trim compensator system actuator are connected by mechanical linkage to the base of the right control column. Stops at the base of the left control column prevent overtravel of the columns.

(5) Load-Feel and Centering Mechanism (See Figure 27-29)

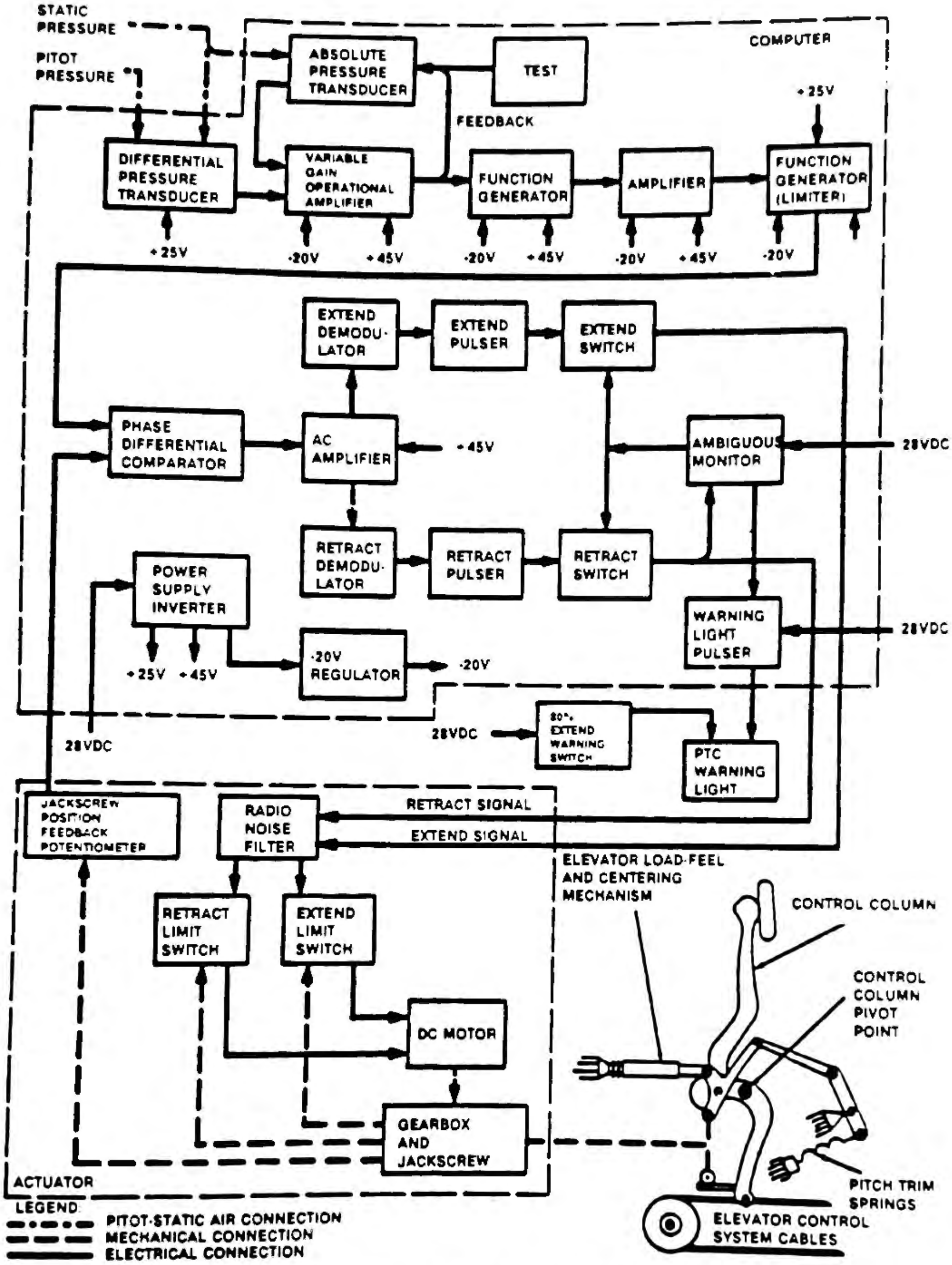
(a) The elevator load-feel and centering mechanism is a spring-loaded device that provides a simulated feel of flight load at the control column. The mechanism also acts as a centering device to return the control system to neutral when the control columns are released.

(b) The mechanism consists of a shaft, inner housing, outer housing, two springs, sliders, internal stops, an adjustable eyebolt, and a fixed end fitting. The shaft is installed in the inner housing and the small spring is held around the shaft by steps on the shaft and in the housing. The inner housing is centered within the outer housing by the sliders. The large spring is located around the inner housing between the sliders. Stops on both ends of the shaft prevent overtravel of the shaft. The adjustable eyebolt, installed in the exposed end of the shaft, connects the aft end of the mechanism to a bellcrank on the base of the right control column. The fixed end fitting, installed in the forward end of the outer housing, is attached to the adjacent structure.

(6) Elevator Dampers (See Figure 27-30)

(a) A viscous damper is installed in the leading edge section of each elevator to prevent flutter during flight. Each damper consists of a housing, vented bladder, six stators, rotor shaft, three rotors, and a drive crank.

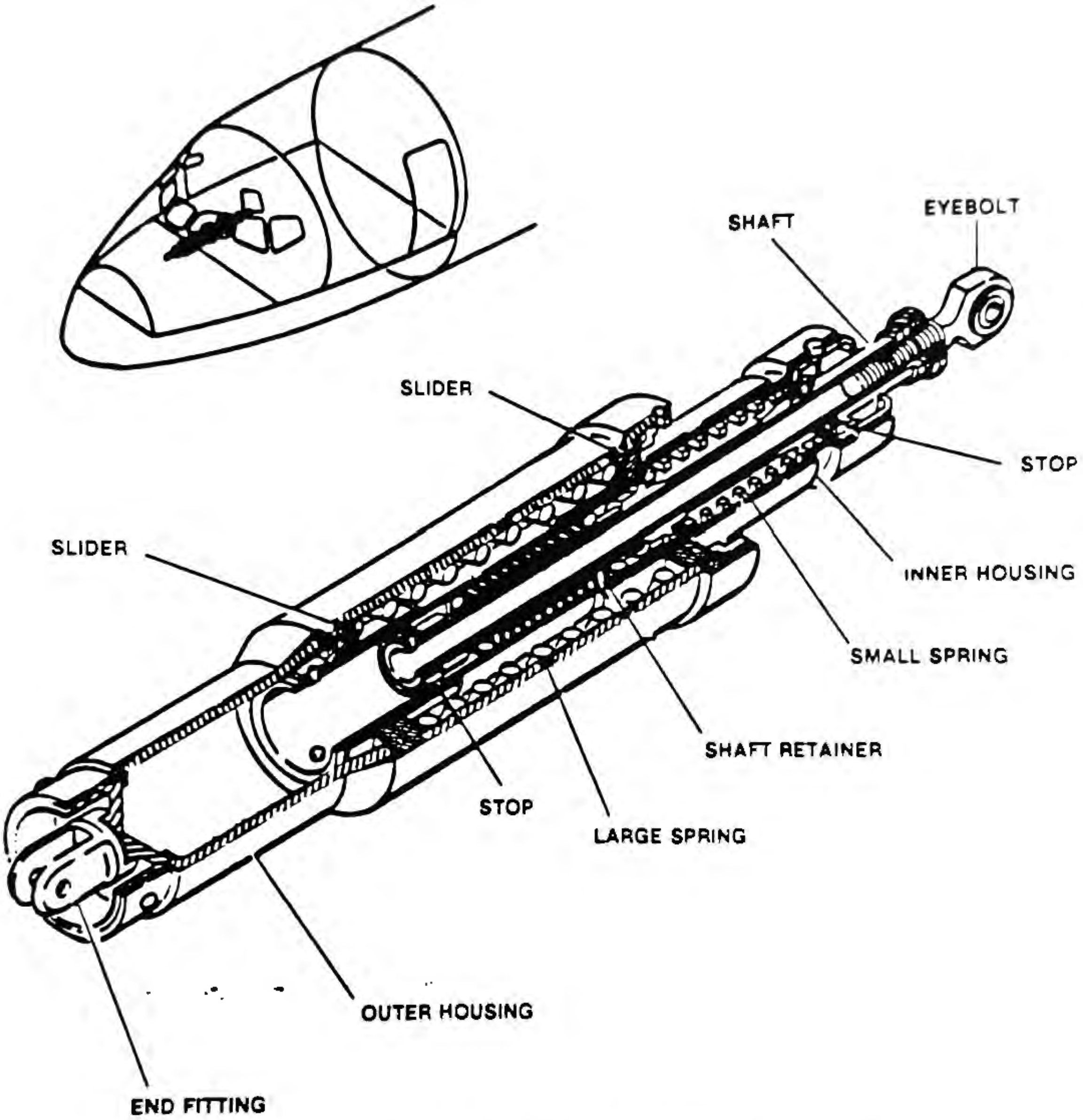
(b) The housing consists of two casing sections bolted together with a cover on each end. One cover contains the bladder and vent; the other cover contains a filler plug which is used to fill the housing with a thick silicone fluid. Two stators are fastened to each casing section and one to each cover so that when the unit is assembled, the stators are positioned in pairs. The three rotors are installed on the shaft, and the shaft is installed in the bearings in each cover so that one rotor is positioned between each pair of stators. The housing is attached to the elevator structure adjacent to the inboard hinge fitting. The drive crank, attached to the exposed end of the rotor shaft, is connected by mechanical linkage to a fitting on the horizontal stabilizer rear spar.



PITCH (MACH) TRIM COMPENSATOR SYSTEM--
BLOCK DIAGRAM

FTX80250

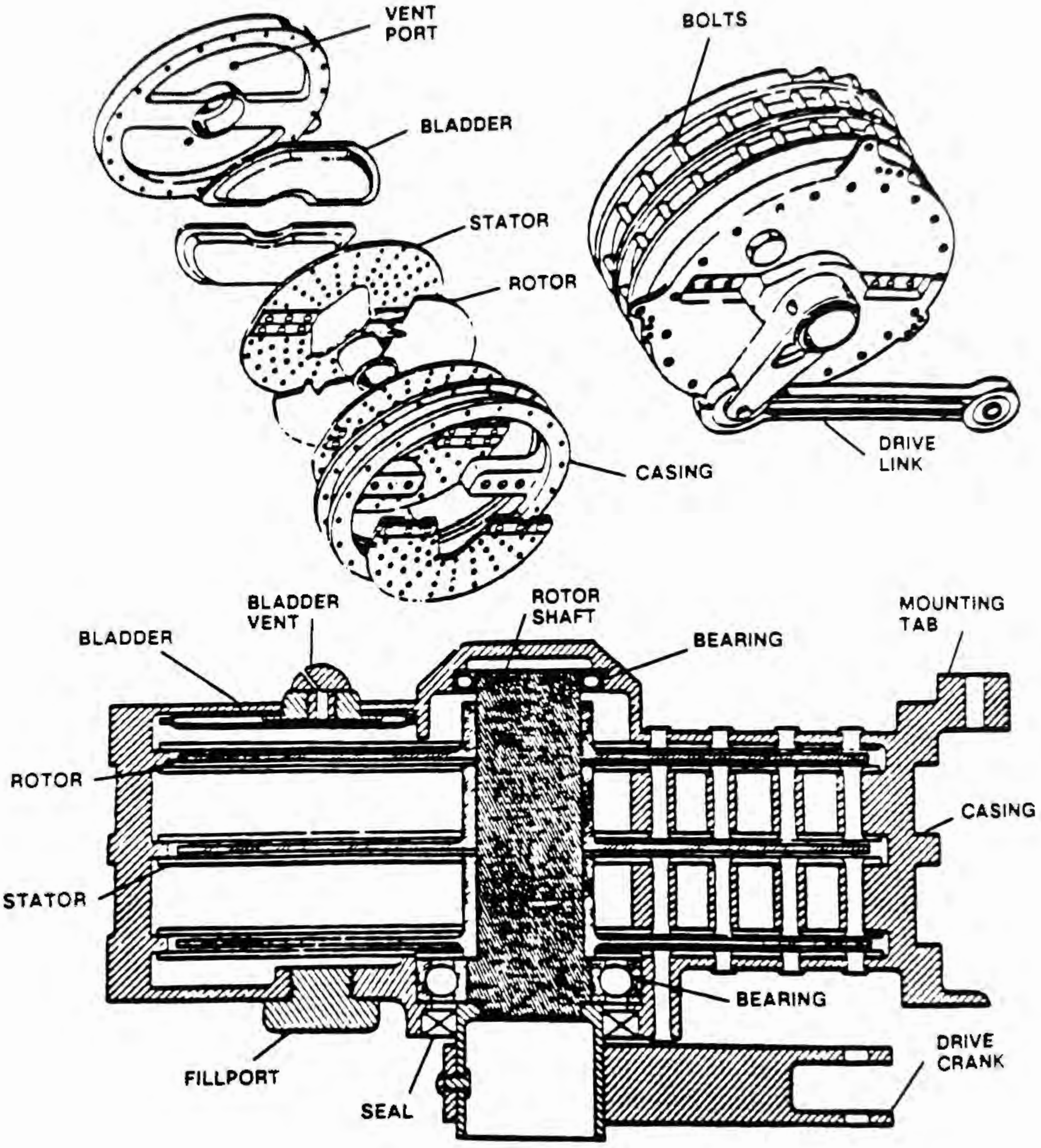
Figure 27-33



ELEVATOR LOAD-FEEL-AND-CENTERING
SPRING MECHANISM -- CUTAWAY

FTX80246

Figure 27-29



ELEVATOR/RUDDER VISCOUS DAMPER -- SCHEMATIC FTX80247

Figure 27-30

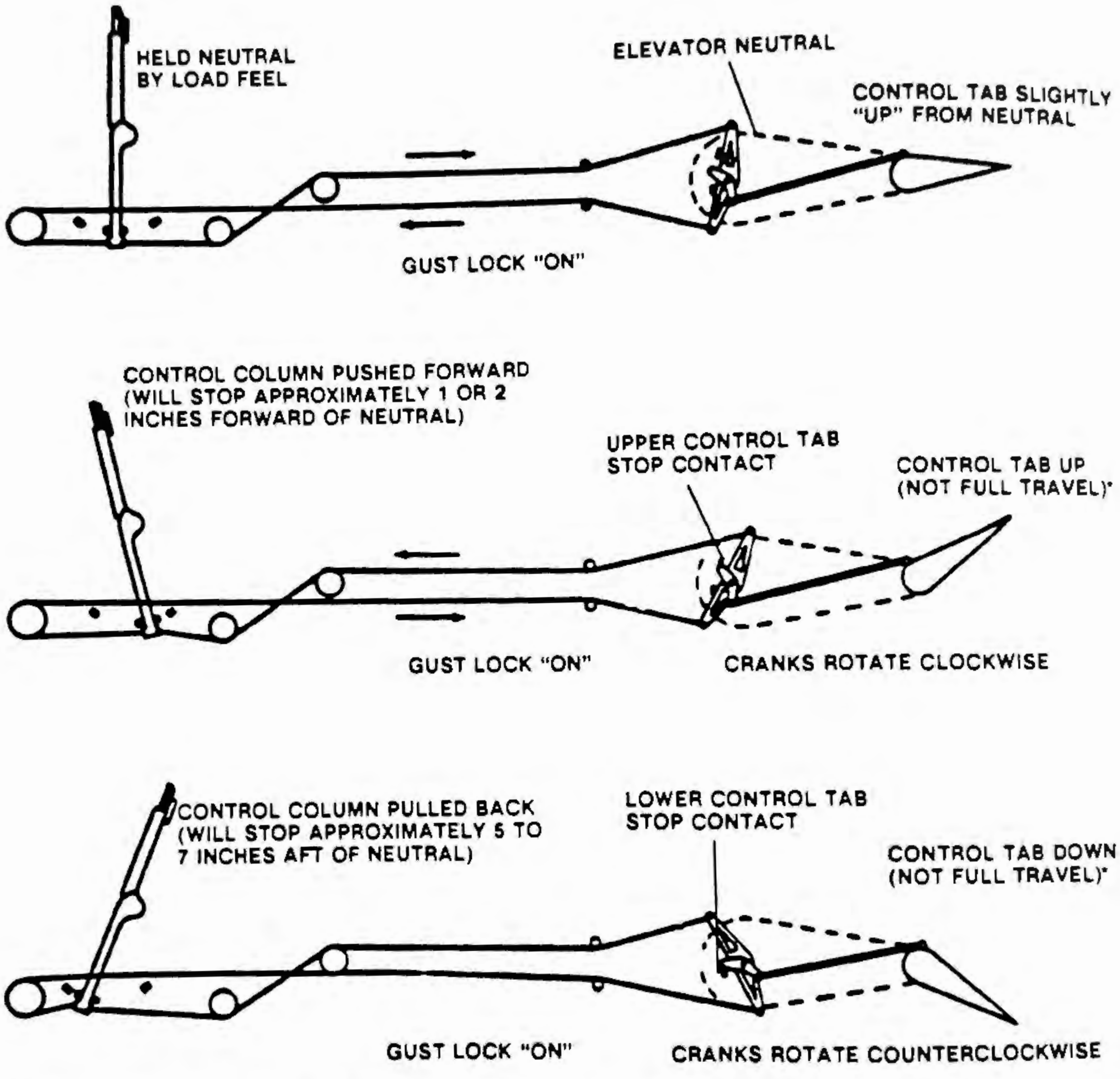
(7) Elevator Control System Operation

(a) When either control column is moved forward or aft, the control column torque tube moves the other column in the same direction. The control columns drive the cable systems and mechanical linkage, causing both elevator control tabs to move up or down. During flight, aerodynamic forces on the displaced control tabs drive the elevators. As the position of the elevators change in relation to the horizontal stabilizer, mechanical linkage moves the geared tabs in the same direction as the control tabs, providing additional aerodynamic boost to assist in moving the elevators.

(b) When force is applied to the control columns, the right control column moves the shaft in the load-feel and centering mechanism. The shaft compresses the small spring against the inner housing. The force required to compress the small spring increases until it is greater than the force required to compress the large spring. At this point, the small spring moves the inner housing against the sliders, compressing the large spring. The resistance of the springs increases as the shaft moves away from the neutral position, providing the simulated load-feel at the control columns. When force is removed from the control columns, the springs return to their neutral positions, causing the control columns to return to the neutral position.

(c) When the airplane is on the ground, control column travel is restricted by the gust lock system and by the control tab stops (see Figures 27-31 & 27-32). Full forward or aft movement of the control columns can be obtained if the elevators are first moved by hand to the corresponding full up or down position and the gust lock control lever is in the unlocked position.

(d) As the elevator moves, the damper drive crank rotates the rotor shaft and rotors within the damper housing. The thick silicone fluid resists the movement of the rotors between the stators. The force required to rotate the shaft is equal to the internal resistance of the damper and is proportional to the speed of the motion. Normal movement of the elevators is slow and is met with little resistance from the dampers. Rapid movement, such as that caused by flutter, is met with greater resistance from the dampers.

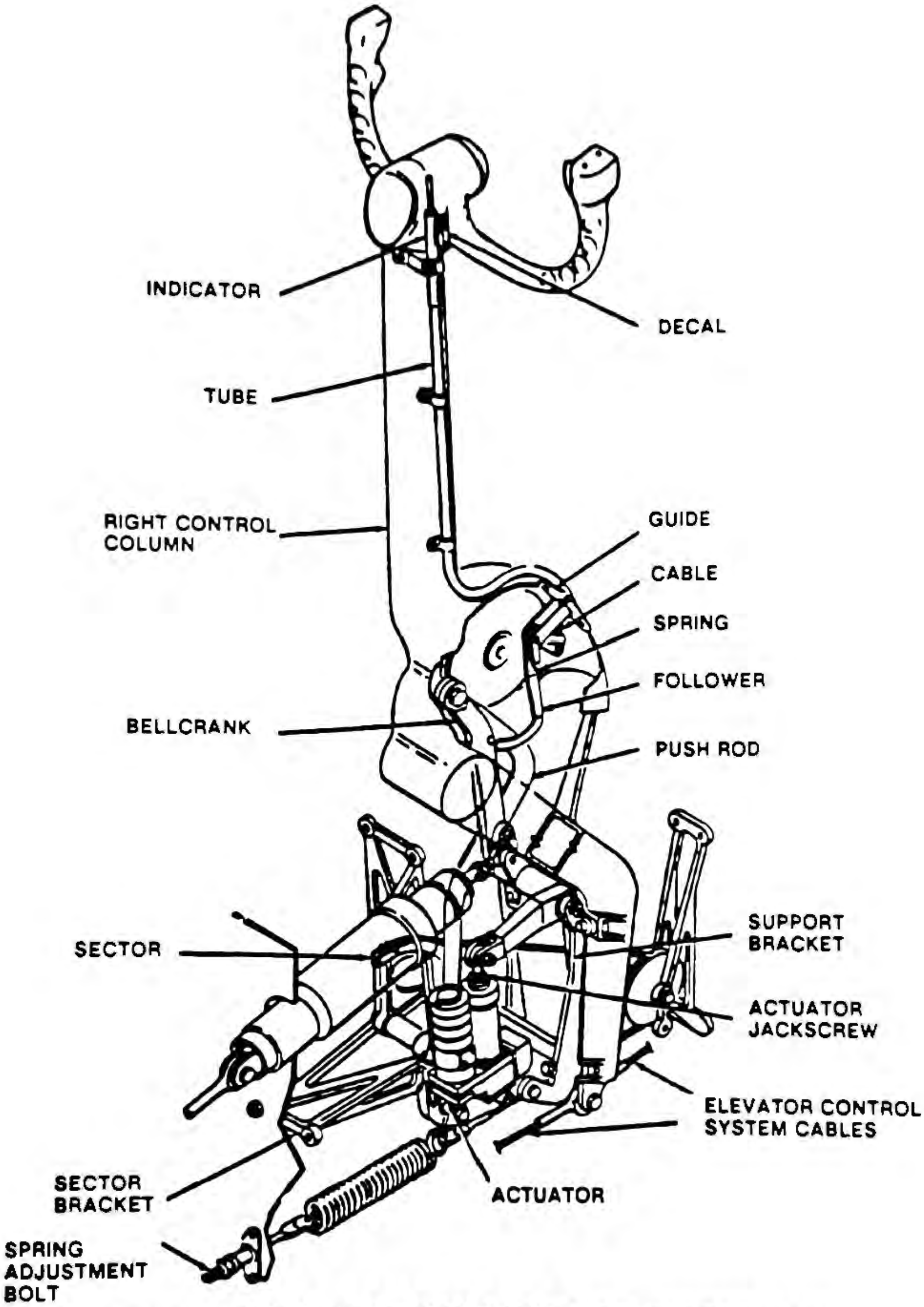

HELD NEUTRAL BY LOAD FEEL
ELEVATOR NEUTRAL
CONTROL TAB SLIGHTLY "UP" FROM NEUTRAL
GUST LOCK "ON"
CONTROL COLUMN PUSHED FORWARD (WILL STOP APPROXIMATELY 1 OR 2 INCHES FORWARD OF NEUTRAL)
UPPER CONTROL TAB STOP CONTACT
CONTROL TAB UP (NOT FULL TRAVEL)*
GUST LOCK "ON"
CRANKS ROTATE CLOCKWISE
CONTROL COLUMN PULLED BACK (WILL STOP APPROXIMATELY 5 TO 7 INCHES AFT OF NEUTRAL)
LOWER CONTROL TAB STOP CONTACT
CONTROL TAB DOWN (NOT FULL TRAVEL)*
GUST LOCK "ON"
CRANKS ROTATE COUNTERCLOCKWISE

*FULL CONTROL TAB TRAVEL CAN ONLY BE OBTAINED WITH GUST LOCK "OFF" AND ELEVATOR CONTROL SURFACE PLACED AGAINST ITS OWN STOP IN THE APPROPRIATE DIRECTION.

CONTROL COLUMN VERSUS
CONTROL SURFACE POSITION (GROUND)

FTX80248

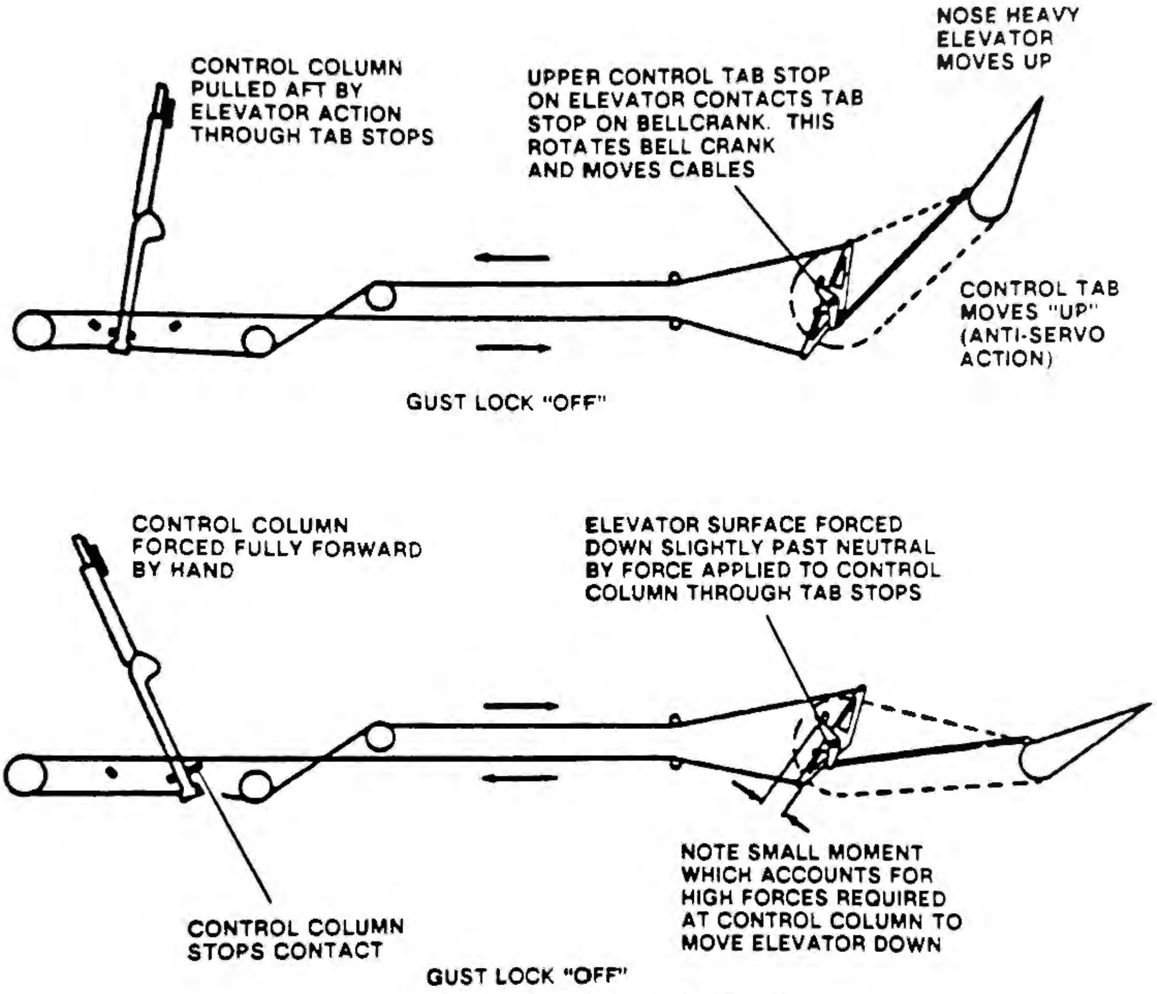
Figure 27-31



PITCH (MACH) TRIM COMPENSATOR ACTUATOR AND MECHANICAL LINKAGE

FTX80252

Figure 27-35


CONTROL COLUMN PULLED AFT BY ELEVATOR ACTION THROUGH TAB STOPS
UPPER CONTROL TAB STOP ON ELEVATOR CONTACTS TAB STOP ON BELLCRANK. THIS ROTATES BELL CRANK AND MOVES CABLES
NOSE HEAVY ELEVATOR MOVES UP
CONTROL TAB MOVES "UP" (ANTI-SERVO ACTION)
GUST LOCK "OFF"
CONTROL COLUMN FORCED FULLY FORWARD BY HAND
ELEVATOR SURFACE FORCED DOWN SLIGHTLY PAST NEUTRAL BY FORCE APPLIED TO CONTROL COLUMN THROUGH TAB STOPS
NOTE SMALL MOMENT WHICH ACCOUNTS FOR HIGH FORCES REQUIRED AT CONTROL COLUMN TO MOVE ELEVATOR DOWN
CONTROL COLUMN STOPS CONTACT
GUST LOCK "OFF"

CONTROL COLUMN VERSUS
CONTROL SURFACE POSITION (GROUND)

FTX80249

Figure 27-32

C. Pitch (Mach) Trim Compensator System (See Figures 27-33 & 27-34)

(1) The pitch (Mach) trim compensator system compensates for the pitching moment of the airplane which occurs when the center of lift moves aft as the airplane approaches the speed of sound. A computer converts airspeed to a Mach number (a number representing the ratio of airspeed to the speed of sound), which is then prgrammed through the computer to an actuator. The actuator supplies corrective forces to the elevator control system by repositioning the control columns and the load-feel and centering mechanism. As airspeed is reduced, the corrective force is reduced until the elevator control system is back to normal. The pitch trim compensator system is operative through Mach numbers 0.7 to 0.95. The system consists of a computer, actuator, mechanical linkage, mechanical indicator, and an electrical indicator.

(2) Computer

(a) The computer, located in the pilot's left-hand console, is the controlling unit of the pitch trim compensator system. Pitot and static pressure input is converted within the computer to an extend or retract command signal which is used to operate the actuator. The computer is an electropneumatic component consisting of a transducer unit, power supply, and several solid-state modules and circuit boards.

(b) The transducer unit has a absolute pressure transducer and a differential pressure transducer. Static air pressure operates the absolute pressure transducer to produce a static pressure analog voltage. The differential pressure transducer, operated by a combination of static and pitot pressure, produces an indicated airspeed analog voltage. The two analog voltages are algebraically summed to create a single pressure-ratio signal (Mach number reference voltage).

12. Horizontal Stabilizers - Description and Operation

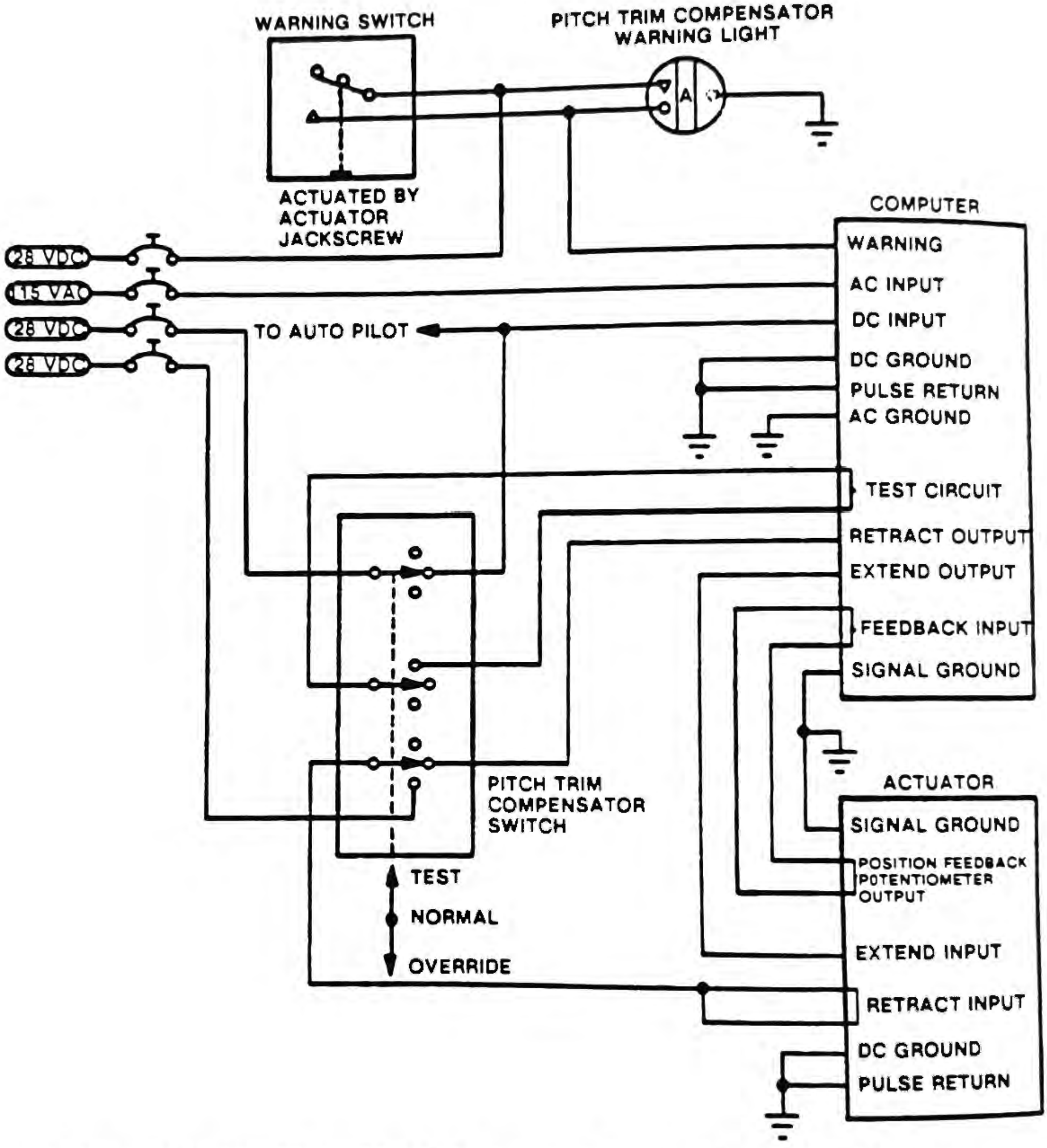
A. General

(1) The horizontal stabilizer is hinged to the aft fuselage structure so that the stabilizer leading edge can be moved up or down to provide longitudinal trim. Approximate travel of stabilizer leading edge is 1/2 degree up or 10 1/8 degrees down from the neutral position. Movement of the stabilizer is controlled from the flight compartment by the longitudinal trim control system or the alternate longitudinal trim control system. The amount of trim obtained is indicated by the longitudinal trim indicating system.

(2) The longitudinal trim control system is hydraulically actuated system that can be controlled manually or electrically. Manual control is provided by the control handles on the pilot's control pedestal. The handles are connected by cable systems to a hydraulic control valve and a hydraulic shutoff valve. The two valves control the supply of hydraulic pressure to a hydraulic motor and brake, which, through a gearbox and sprocket and chain mechanism, drives two jackscrews to move the stabilizer. Electrical control is provided by dual switches mounted in the outboard horn of each aileron control wheel. The switches control the clutches in two servo actuators, which drive the same cable systems that actuate the hydraulic components during mechanical control. Travel limit stops on the stabilizer forward spar actuate the hydraulic shutoff valve to halt stabilizer travel when travel limit is reached. Rate of trim when using the longitudinal trim control system is approximately 1/3 degree per second.

(3) The alternate longitudinal trim control system uses an electric motor as an alternate method of driving the gearbox to actuate the jackscrews and move the stabilizer. The electric motor is controlled by two switches actuated by levers located on the pilot's control pedestal. The travel limit stops on the stabilizer forward spar actuate a limit switch to halt stabilizer travel when limit of travel is reached. Rate of trim using the electric motor is approximately 1/20 of the rate obtained when using the hydraulic motor.

(4) The longitudinal trim indicating system is a mechanical system. A pointer, located on the pilot's control pedestal, is connected by cable systems to a bracket on the stabilizer forward spar. As either control system moves the stabilizer, the indicating system cables move the



PITCH (MACH) TRIM COMPENSATOR SYSTEM-- SCHEMATIC FTX80251

Figure 27-34

(c) The output of the transducer unit is amplified, shaped, and isolated from local effects by a variable gain operational amplifier. Gain is facilitated by a feedback loop to the absolute pressure transducer. The amplifier output is applied to a function generator circuit which converts the amplified signal to an actuator position command signal. This signal is amplified by a second amplifier and the top portion of the signal is shaped and limited by a second function generator and fed into a phase differential comparator. The output of the actuator jackscrew position feedback potentiometer is also applied to the comparator.

(d) The output of the actuator jackscrew position feedback potentiometer is also applied to the comparator. The comparator is an error detector which compares the actuator position command signal and the actuator position feedback signal to produce an error voltage. This error voltage is amplified and fed into a phase demodulation circuit. The demodulation circuit excites a pulse modulation circuit to energize an extend or retract switch depending on the phase of the error voltage. The switch output is the extend or retract command signal that is transmitted to the actuator.

(e) A test circuit permits the computer to be tested on the ground. When the press-to-test switch is operated, a simulated Mach number reference voltage is applied to the function generator causing the computer to command extension of the actuator jackscrew. An ambiguity monitor circuit monitors the extend and retract channels. If both channels fire simultaneously, the monitor circuit functions to shut off the computer and cause a PTC warning light on the main instrument panel to flash on and off, indicating that the computer is disabled. The power supply includes inverter and regulator circuits to obtain the various voltages required by different sections of the computer.

(3) Actuator

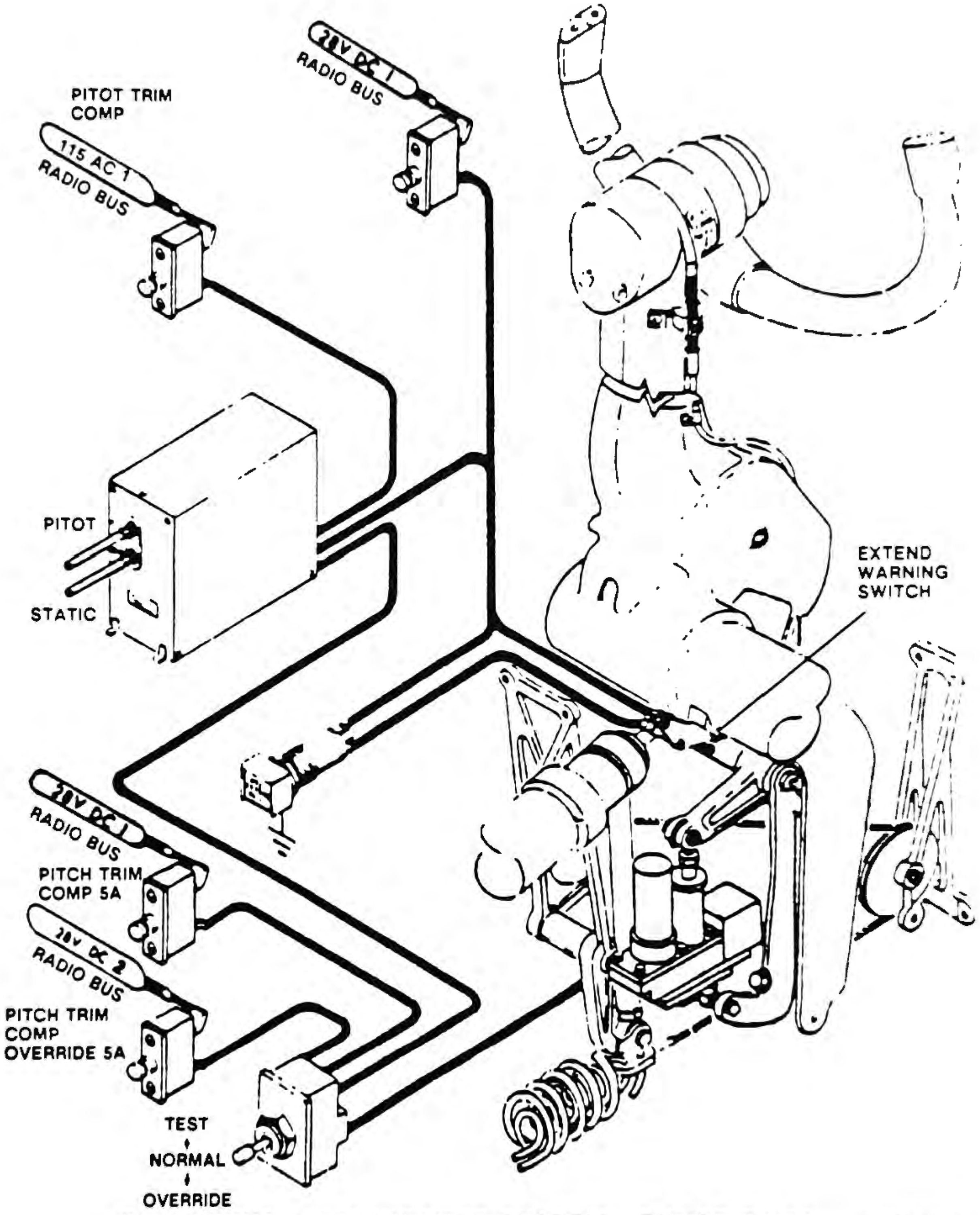
(a) The actuator consists of a radio noise filter, extend limit switch, retract limit switch, reversible dc motor, gearbox, jackscrew and nut, and a jackscrew position feedback potentiometer. Electrical input to the actuator is supplied from the output of the computer.

The jackscrew is connected by mechanical linkage to the base of the right elevator control column. The feedback potentiometer is connected electrically to the feedback inputs of the computer.

(b) The dc command signal from the computer is applied through the radio noise filter and one of the limit switches to the windings of the dc motor, causing the motor output shaft to rotate. Rotation of the motor output shaft is transferred through the gearbox, to rotate the jackscrew within the nut. Since the nut is fixed to the actuator housing, the jackscrew extends or retracts, causing the mechanical linkage to move the load-feel and centering mechanism and the control column. As the jackscrew reaches the limit of its travel, further rotation of the jackscrew causes the arm to open the contacts of the extend or retract limit switch, as applicable, cutting off the signal to the motor windings. Rotation of the jackscrew also positions the feedback potentiometer which transmits a signal, representing the position of the jackscrew, to the computer.

(4) Actuator Mechanical Linkage (See Figures 27-35 & 27-36)

(a) The actuator mechanical linkage consists of a support bracket, bellcrank, sector, sector bracket, pushrod, cable, and two springs. The actuator is mounted on a support bracket which is installed on the lower leg of the right control column. The actuator jackscrew and the elevator load-feel and centering mechanism are connected to a bellcrank which is installed on the upper end of the support bracket. The sector is supported by a sector bracket which is attached to the structure forward of the actuator. A pushrod connects an arm on the sector to an arm on the bellcrank. A cable, attached to the sector, is routed around a pulley and connected to two springs which are attached to the structure. The spring attach bolt is adjustable to allow spring tension to be adjusted.



PITCH TRIM COMPENSATOR SYSTEM - FUNCTIONAL FTX80253
Figure 27-36

B. Component Description

(1) Roller Chain and Jackscrew Mechanism (See Figure 27-39)

(a) The roller chain and jackscrew mechanism consists of two jackscrews, two jackscrew sprockets, nuts, jackscrew bearing housing, two roller chains, drive sprocket, and sprocket housing.

(b) A clevis on the upper end of each jackscrew is attached to a fitting on the forward spar of the horizontal stabilizer. Each jackscrew sprocket is attached to a nut that is threaded around the lower end of the jackscrew. The nut is mounted in a bearing and housing that is attached to the empennage structure. An anti-rotation bar, installed around the upper end of each jackscrew, is attached to a bracket on the horizontal stabilizer forward spar. Mechanical stops, installed on each jackscrew, and nut above and below the sprockets prevent overtravel of jackscrews. The sprocket housing is installed on a support attached to the empennage structure below the horizontal stabilizer drive unit. The drive sprocket, mounted in the bearings within the housing, is connected to the output shaft of the drive unit gearbox. Roller chains connect the drive sprocket to each jackscrew sprocket. Chain tension is adjusted by turnbuckles that connect the sprocket housing to each jackscrew bearing housing.

(2) Horizontal Stabilizer Drive Unit (See Figure 27-40)

(a) The horizontal stabilizer drive unit consists of a gearbox, hydraulic brake, hydraulic motor, control valve, and shutoff valve. The alternate longitudinal trim control system electric motor is mounted on the drive unit.

(b) The gearbox (see Figure 27-41) is a two-stage plentary gear assembly installed in a housing mounted on top of the roller chain sprocket housing. The hydraulic brake torque shaft and the alternate longitudinal trim control system electric motor output shaft are connected to the first-stage gears. The second-stage gears are connected to a splined output shaft that fits into the hub of the roller chain drive sprocket. A filler plug is installed in the side of the gearbox housing to permit replenishment of gearbox lubricant.

(b) When the actuator jackscrew extends or retracts, the bellcrank is rotated causing the load-feel and centering mechanism shaft to move. At the same time, the arm of the bellcrank moves the pushrod to drive the sector, causing the cable to alter the tension on the two springs. Change in tension of the two springs, plus compression of the springs in the centering mechanism, causes the elevator control column to move to a new neutral position. Movement of the control column drives the elevator control system cables to apply compensating trim to the elevators.

(5) Pitch Trim Mechanical Indicator

(a) The mechanical indicator, located on the inboard side of the right control, column, provides visual indication of the approximate position of the actuator jackscrew. The indicator consists of a follower, two springs, tube, guide, indicator cable, and a decal. The follower is installed inside the lower end of the control column. The two springs are located around the hub of the follower and exert a force to keep the follower crank in contact with an arm on the actuator mechanical linkage. The guide is attached to the control column at the lower end of the tube. The indicator cable is installed in the tube and routed through the guide to an arm on the follower. A graduated rod on the end of the cable protrudes from the upper end of the tube. The decal, adhered to the column adjacent to the indicator rod, indicates the direction that the rod must travel for maximum or minimum pitch trim.

(b) As the actuator jackscrew extends, the arm on the bellcrank of the actuator mechanical linkage moves the follower crank. As the actuator jackscrew retracts, the follower springs cause the follower crank to follow the arm on the bellcrank. The follower moves the indicator cable up or down within the tube. Approximate position of the jackscrew (pitch trim applied by actuator) is indicated by the amount of rod protruding from the end of the tube: as more pitch trim is applied, more of the indicator rod becomes visible.

(6) Electrical Warning Indicator

(a) The electrical indicator provides visual warning when the PTC actuator is extended 80 percent or more. The indicator consists of a switch and a warning light. The switch is attached to the elevator control column torque tube with the switch actuator positioned above the actuator jackscrew. The light is located on the instrument panel.

(b) When the actuator jackscrew is extended 80 percent of its travel, the switch actuator is contacted. The normally open contacts in the switch are closed, completing 28-vdc circuit and causing the light to come on. the light remains on until the actuator jackscrew retracts to less than 80 percent of extension, when the switch contacts are opened and the circuit to the light is interrupted.

(c) The warning light is also connected to the ambiguous monitor circuit in the computer. If the monitor circuits shuts off the computer, the light flashes on and off, indicating that the computer is disabled.

(7) Pitch Trim Compensator Switch

(a) The pitch trim compensator switch, located on the pilot's control pedestal, has three positions: normal, test, and override. When the switch is in the normal position, the pitch trim compensating system functions normally, applying switch compensating trim to the elevator system as commanded by the computer. When the switch is in the override position, 28-vdc electrical power is applied directly to the actuator retract input, overriding any computer command and causing the actuator jackscrew to retract.

(b) Test position of the switch allows the system to be tested while the airplane is on the ground. When the switch is in the test position, electrical power is applied to the computer test circuit which then simulates a full reference (Mach number) voltage, causing the actuator jackscrew to extend. As the jackscrew extends, the pitch trim mechanical indicator rod extends toward the maximum position.

pointer to show the amount of trim. A sensor, actuated by the indicating system, provides an audible warning when the stabilizer is in motion.

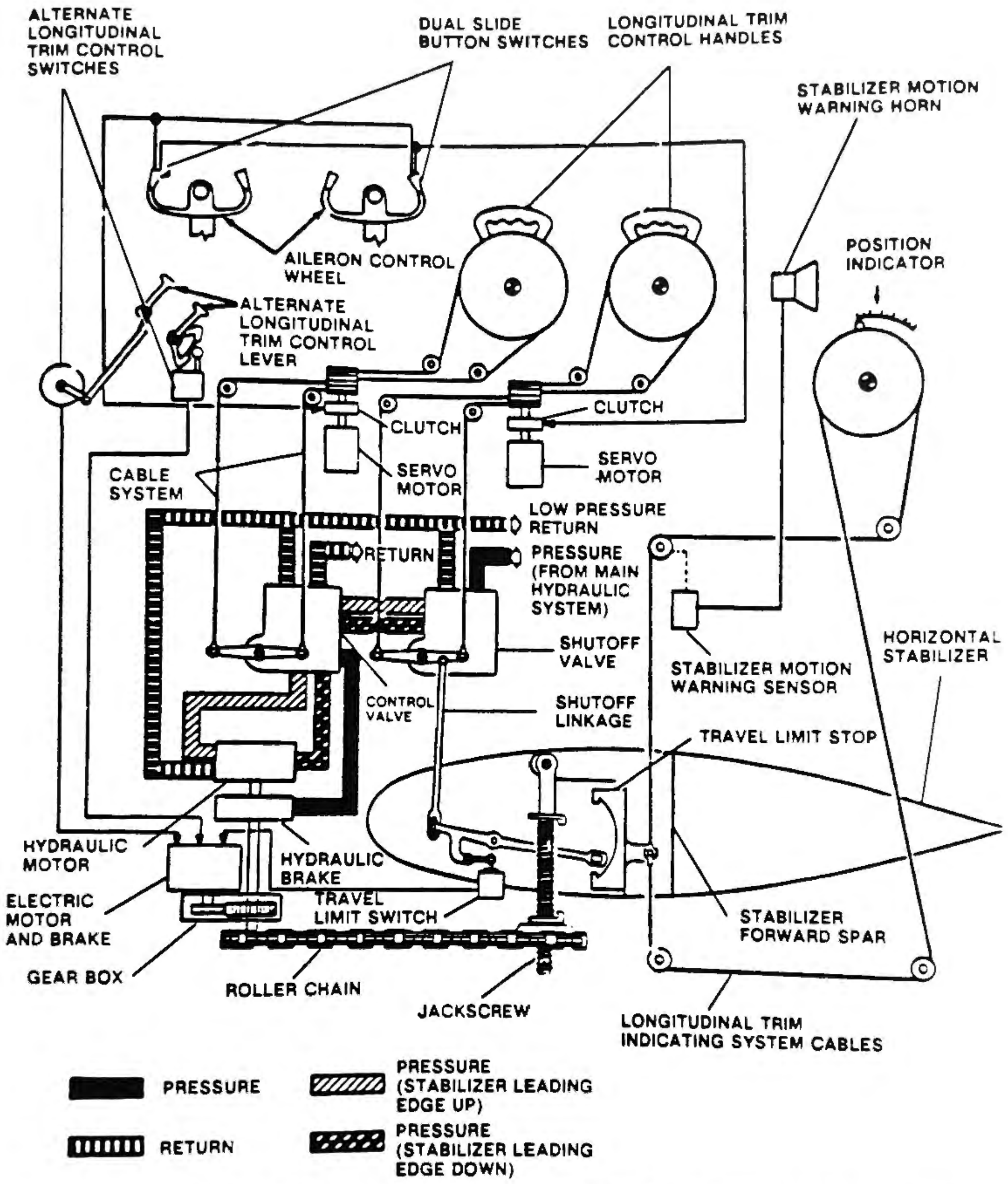
13. Longitudinal Trim Control System - Description and Operation

A. General (See Figures 27-37 & 27-38)

(1) The longitudinal trim control system is a hydraulically actuated system that controls the movement of the horizontal stabilizer to provide longitudinal trim. The system can be manually or electrically controlled from the flight compartment. The system consists of the following major components.

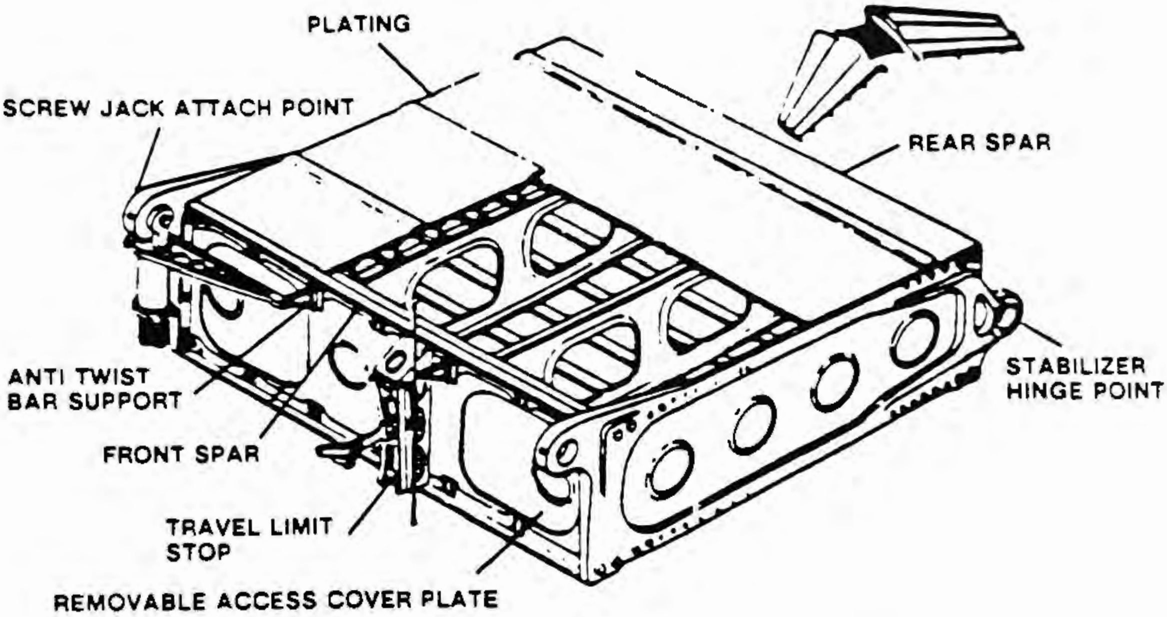
Component	Location
Two longitudinal trim control handles	Pilot's control pedestal, in flight compartment
Roller chain and jackscrew mechanism	Aft fuselage section
Horizontal stabilizer drive unit	Aft fuselage section
Longitudinal trim dual slide button switches	Outboard horn of each aileron control wheel, in flight compartment
Two servo actuators	Center section accessory compartment

(2) The longitudinal trim control handles are attached to sectors installed on the main lever shaft in the pilot's control pedestal. A two-way cable system, connected to the inboard sector, is routed through the fuselage to a crank on the horizontal stabilizer drive unit control valve. The outboard sector is connected by a similar cable system to a crank on the drive unit shutoff valve. Hydraulic lines connect the shutoff valve to the control valve, and the control valve to the hydraulic motor and brake. The motor and brake are connected through the gearbox to a sprocket located at the base of the drive unit. The sprocket is connected by roller chains to sprockets around the lower ends of two jackscrews. The upper end of each jackscrew is attached to the horizontal stabilizer forward spar. The longitudinal trim dual slide button switches are electrically connected to two actuators. The servo actuators are mechanically connected to the same cable systems that are operated by the control handles.


ALTERNATE LONGITUDINAL TRIM CONTROL SWITCHES
DUAL SLIDE BUTTON SWITCHES
LONGITUDINAL TRIM CONTROL HANDLES
STABILIZER MOTION WARNING HORN
POSITION INDICATOR
AILERON CONTROL WHEEL
ALTERNATE LONGITUDINAL TRIM CONTROL LEVER
CLUTCH
CLUTCH
SERVO MOTOR
SERVO MOTOR
CABLE SYSTEM
LOW PRESSURE RETURN
RETURN
PRESSURE (FROM MAIN HYDRAULIC SYSTEM)
SHUTOFF VALVE
STABILIZER MOTION WARNING SENSOR
HORIZONTAL STABILIZER
CONTROL VALVE
SHUTOFF LINKAGE
TRAVEL LIMIT STOP
HYDRAULIC MOTOR
HYDRAULIC BRAKE
ELECTRIC MOTOR AND BRAKE
TRAVEL LIMIT SWITCH
STABILIZER FORWARD SPAR
GEAR BOX
ROLLER CHAIN
JACKSCREW
LONGITUDINAL TRIM INDICATING SYSTEM CABLES
PRESSURE
PRESSURE (STABILIZER LEADING EDGE UP)
RETURN
PRESSURE (STABILIZER LEADING EDGE DOWN)

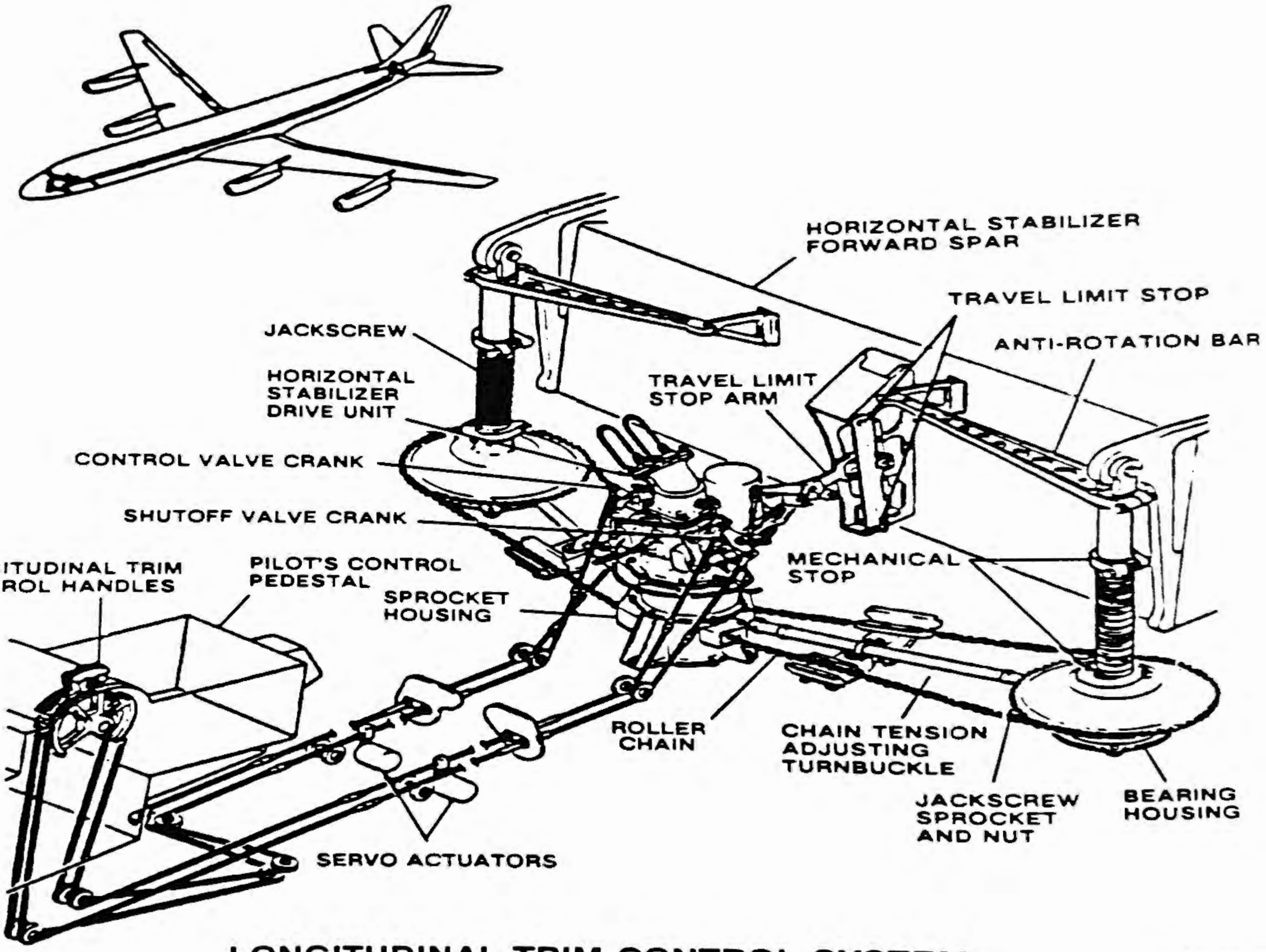
HORIZONTAL STABILIZER SYSTEM -- SCHEMATIC FTX80254

Figure 27-37



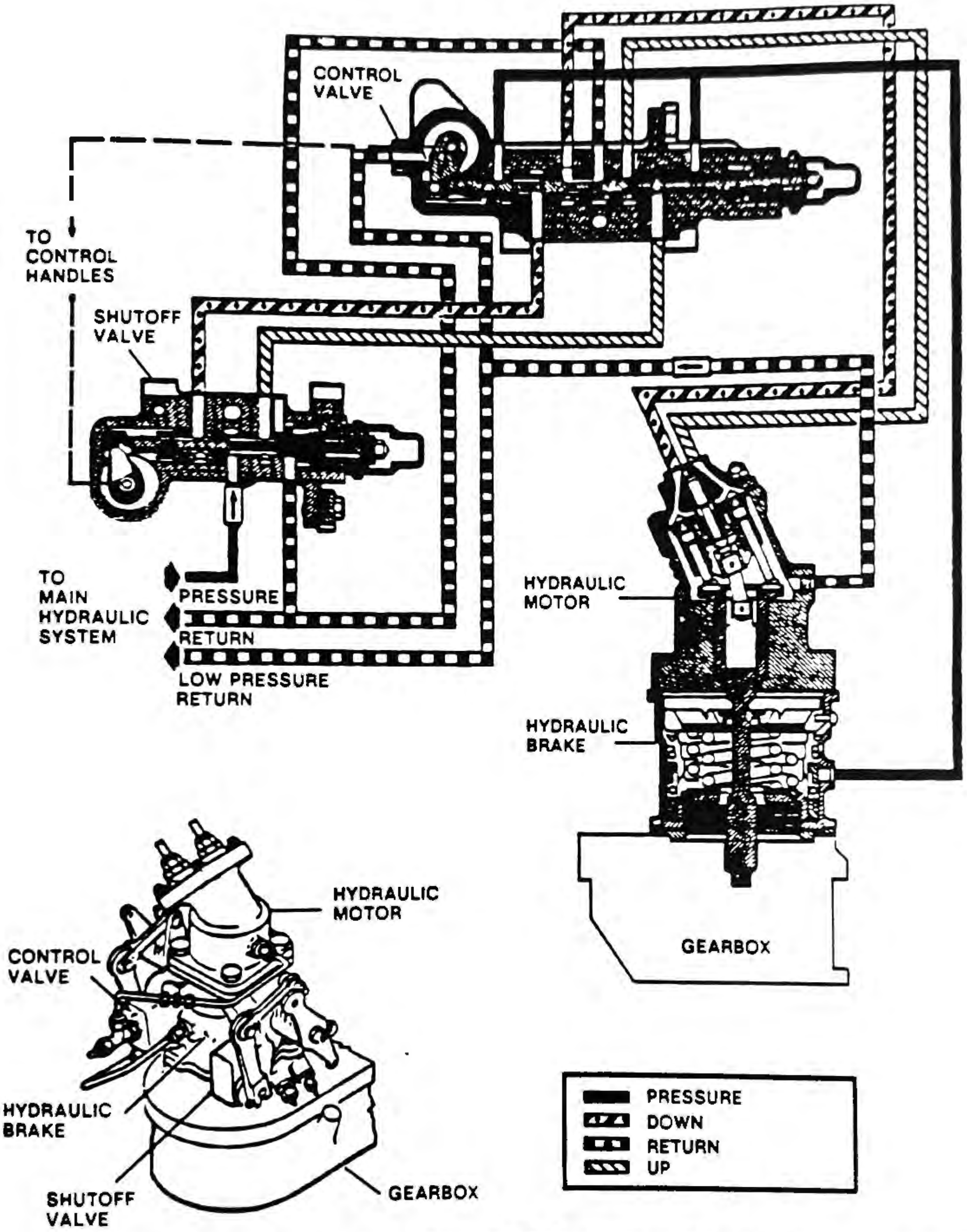
HORIZONTAL STABILIZER STRUCTURE FTX80255

Figure 27-38

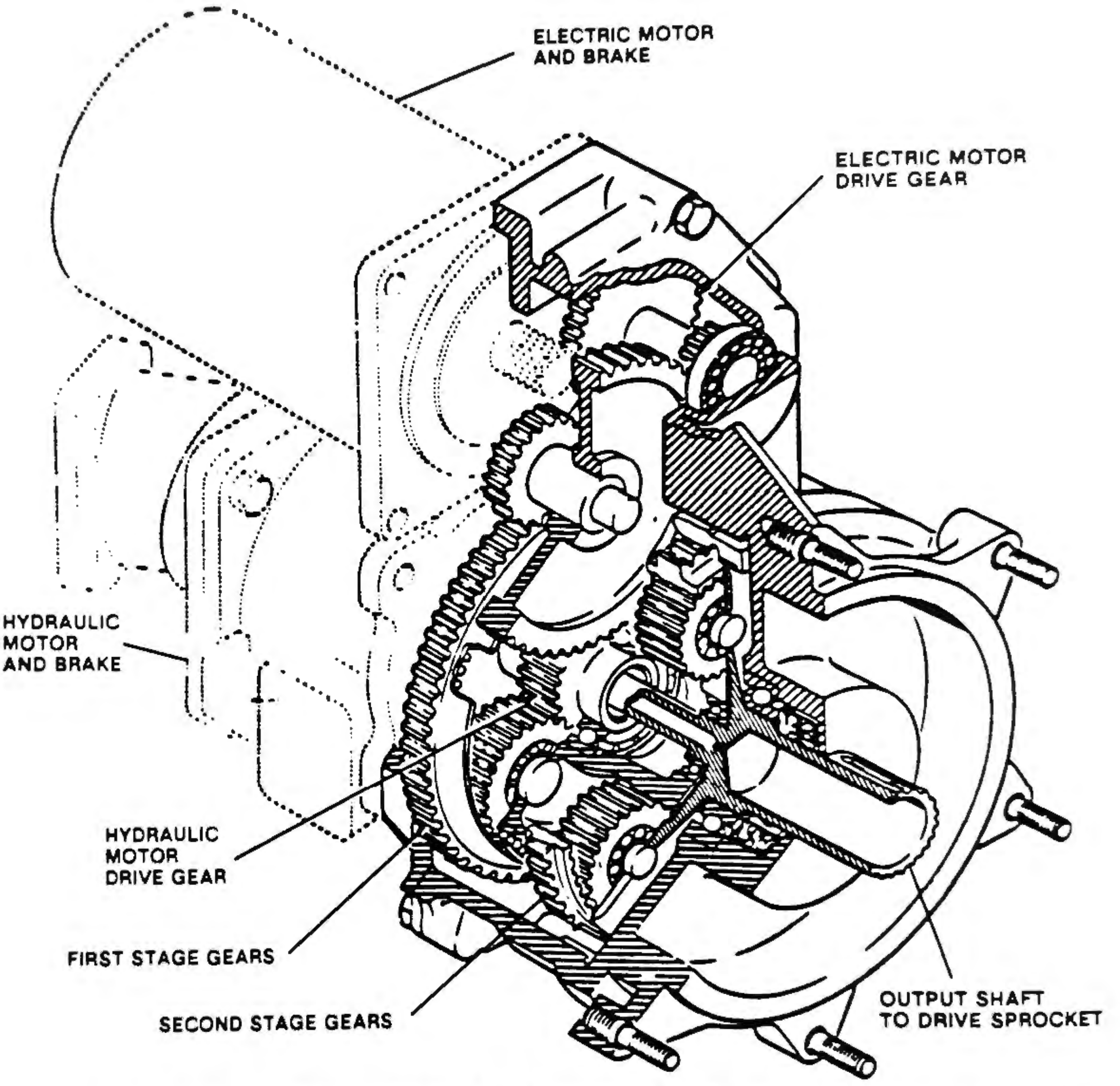


LONGITUDINAL TRIM CONTROL SYSTEM

Figure 27-39



HORIZONTAL STABILIZER DRIVE UNIT -- SCHEMATIC FTX80257
Figure 27-40

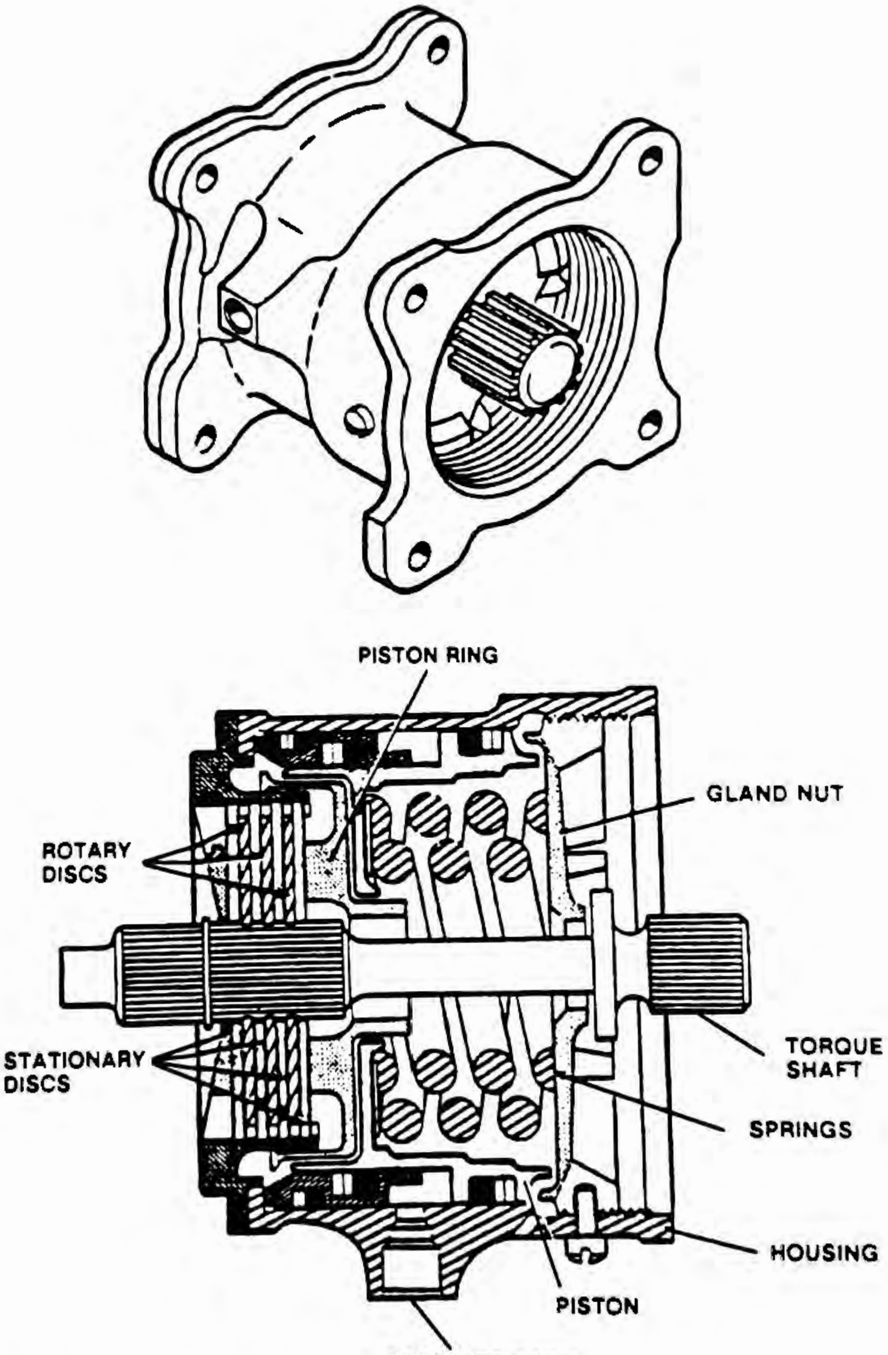

ELECTRIC MOTOR AND BRAKE
ELECTRIC MOTOR DRIVE GEAR
HYDRAULIC MOTOR AND BRAKE
HYDRAULIC MOTOR DRIVE GEAR
FIRST STAGE GEARS
SECOND STAGE GEARS
OUTPUT SHAFT TO DRIVE SPROCKET

HORIZONTAL STABILIZER DRIVE UNIT GEARBOX -- CUTAWAY FTX80258

Figure 27-41

(c) The hydraulic brake (see Figure 27-42) consists of a housing, housing end, four stationary discs three rotary discs, torque shaft, piston ring, piston, two springs, and a gland nut. The stationary discs are installed in grooves in the housing end, which is threaded into the lower end of the housing. The rotary discs, located between the stationary discs, are splined to the torque shaft. The piston ring is positioned around the torque shaft against the discs. The piston is held against the piston ring by the two springs that are secured in the housing by the gland nut. The housing is mounted on top of the gearbox with the lower end of the torque shaft engaged in one of the first-stage gear input shafts. The upper end of the torque shaft is connected to the output shaft of the hydraulic motor. A part on the side of the housing is connected by hydraulic line to the control valve. The brake is normally maintained in the on position by the spring tension, which holds the piston ring against the discs, preventing the torque shaft from rotating. When 600-psi hydraulic pressure is applied to the brake, the spring tension is overcome, and the piston ring releases the discs to allow the torque shaft to rotate.

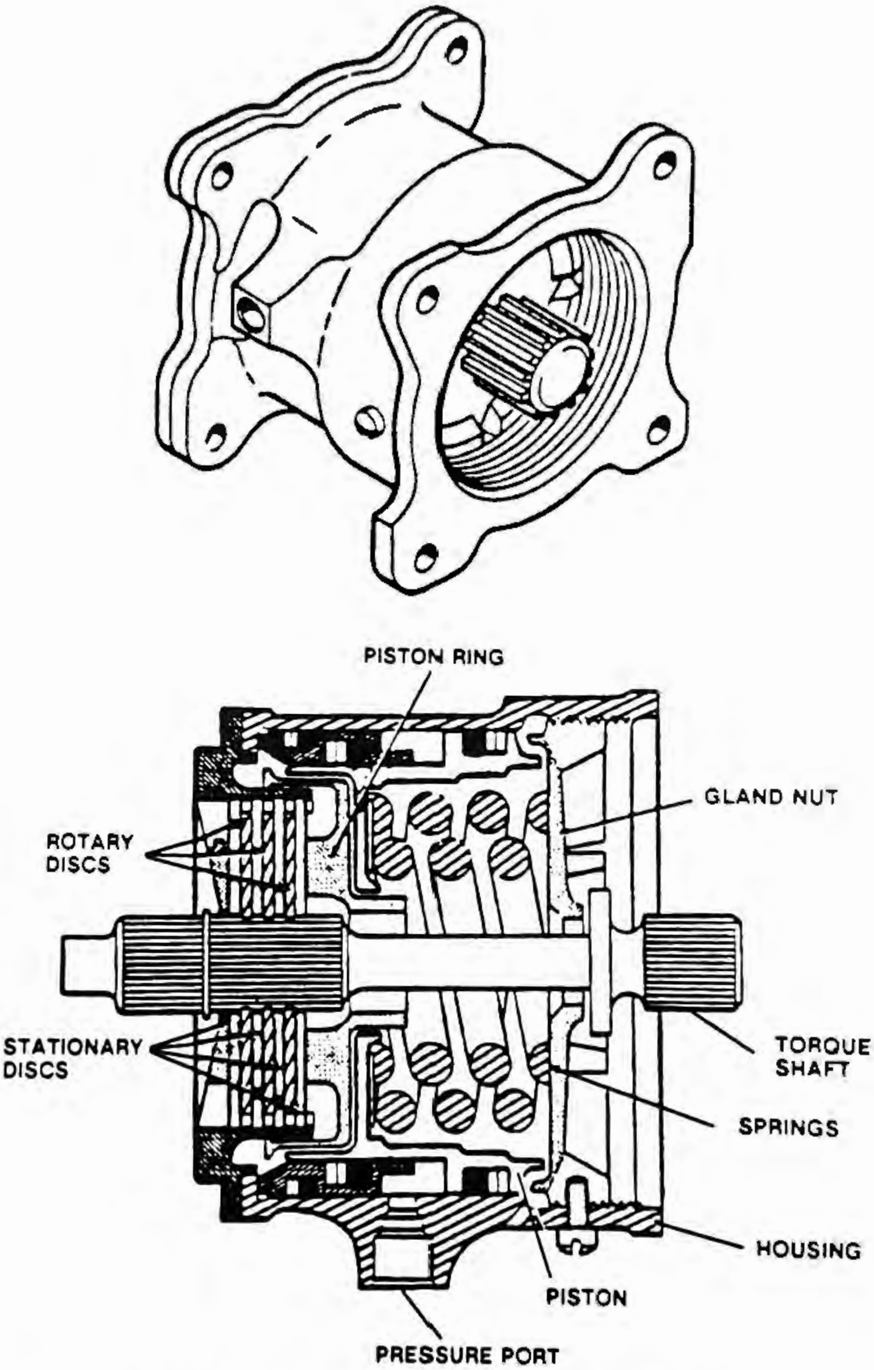
(d) The hydraulic motor (see Figure 27-43) converts hydraulic pressure to rotary mechanical motion to drive an output shaft in a clockwise or counterclockwise direction. The motor, mounted on top of the hydraulic brake, consists of a housing, valve block, cylinder block, universal link, drive shaft, and nine pistons. The upper portion of the housing is offset 30 degrees in relation to the lower portion. The valve block, mounted on the upper end of the housing, has two pressure inlets, connected by hydraulic lines to the control valve. A low-pressure return port is located on the side of the housing. The cylinder block rotates on a bearing pin, which is secured in the valve block by a lockpin. The universal link connects the cylinder block to the drive shaft, which is installed in the lower end of the housing. The pistons, located in individual bores around the perimeter of the cylinder block, are connected to the drive shaft by ball joints. The internally splined drive shaft engages the hydraulic brake torque shaft. When hydraulic pressure is applied to one pressure inlet port, the pressure is directed through the valve block to the pistons in the cylinder block. As the piston bores fill with fluid, the pistons are forced downward. Since the pistons are connected to the drive shaft which is offset 30 degrees in relation to the cylinder block, the downward stroke



HORIZONTAL STABILIZER DRIVE UNIT HYDRAULIC BRAKE -- CUTAWAY

FTX80260

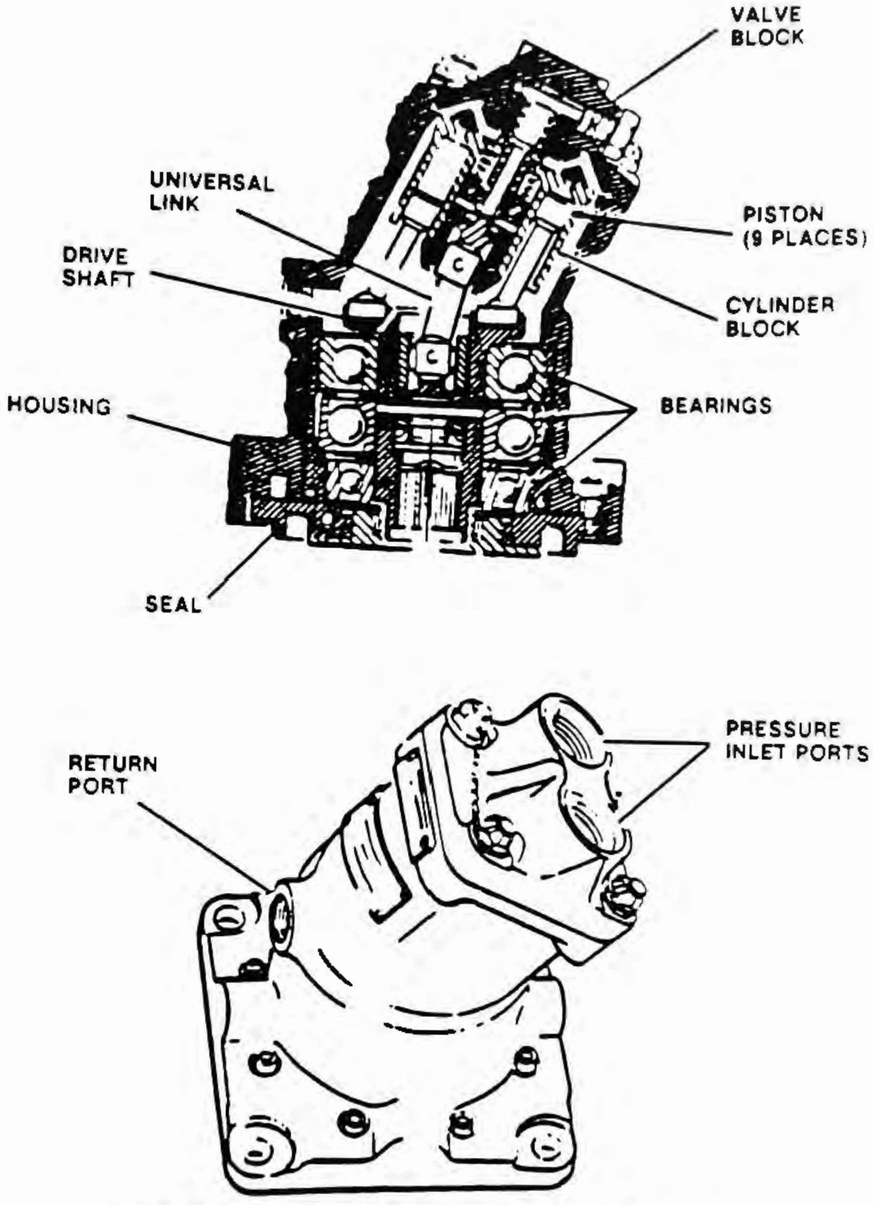
Figure 27-42



HORIZONTAL STABILIZER DRIVE UNIT HYDRAULIC BRAKE -- CUTAWAY

FTX80260

Figure 27-42



HORIZONTAL STABILIZER DRIVE UNIT
HYDRAULIC MOTOR

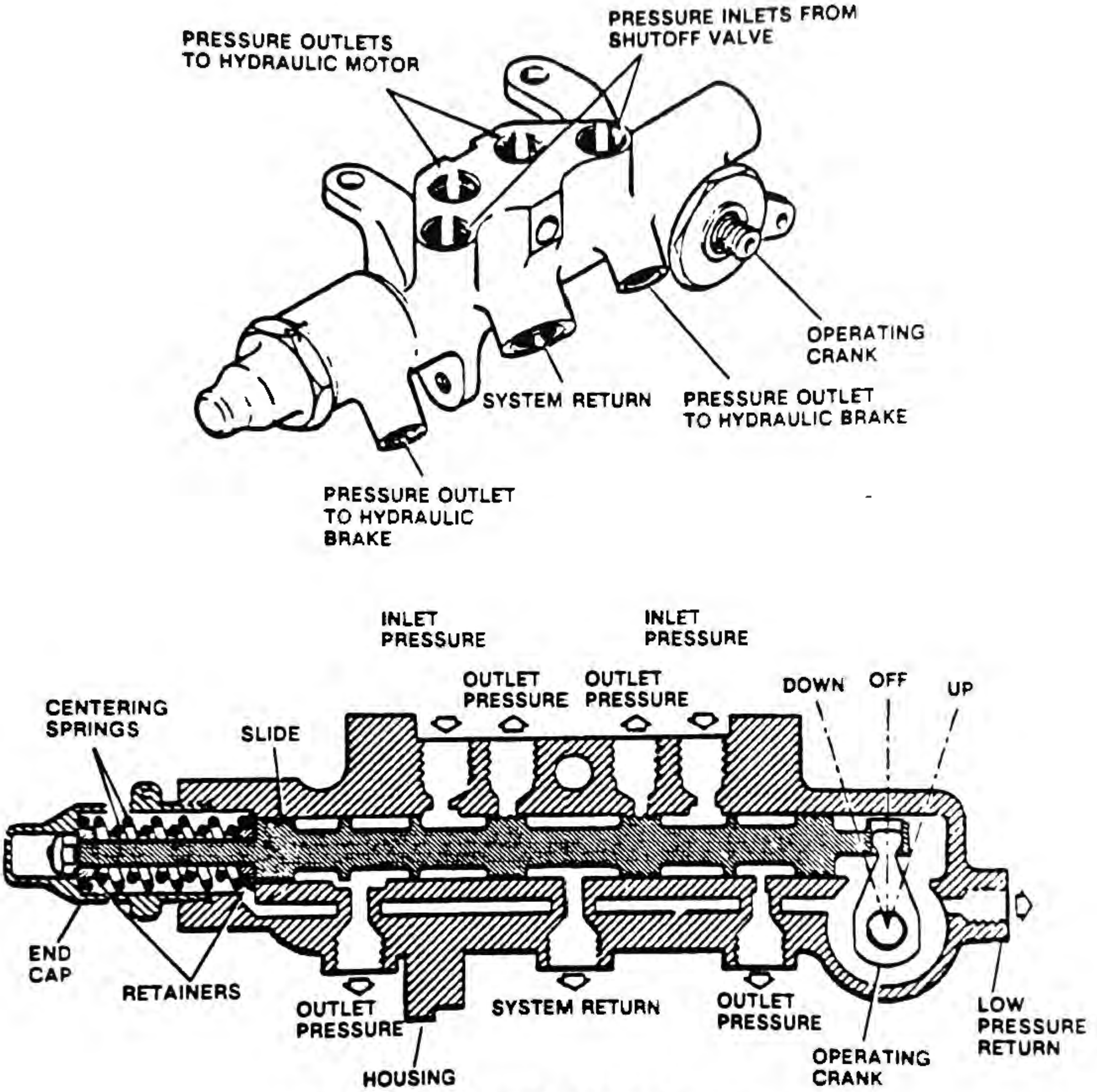
FTX80261

Figure 27-43

of the pistons creates rotary movement of the cylinder block and drive shaft. On the withdrawal stroke of the pistons, fluid is forced under low pressure to the return port. The rotary movement of the drive shaft is reversed if pressure is applied to the opposite pressure inlet port in the valve block.

(e) The hydraulic control valve (see Figure 27-44), mounted on the right side of the hydraulic brake is a mechanically operated slide valve that directs hydraulic pressure to the hydraulic motor and brake. The control valve consists of a housing, slide, two springs, two spring retainers, end cap, and operating crank. The housing has two pressure inlet ports connected to the shutoff valve, two pressure outlet ports connected to a T-fitting upstream of the hydraulic motor to drive the motor clockwise, a pressure outlet port connected to the hydraulic motor to drive the motor counterclockwise, and two return ports connected to the main hydraulic system. The slide is maintained in the neutral position by the two springs that are installed on the slide between the two retainers. The retainers are positioned against steps in the housing and end cap. The crank, attached to the end of the slide, is connected by mechanical linkage and cable system to the right longitudinal trim control handle. The lands on the slide are located so that movement of the crank directs hydraulic pressure to simultaneously release the hydraulic brake and drive the motor clockwise or counterclockwise, depending on the direction that the crank is moved from the neutral position.

(f) The hydraulic shutoff valve (See Figure 27-45), mounted on the left side of the hydraulic brake, is a mechanically operated slide valve that controls the supply of hydraulic pressure from the main hydraulic system to the control valve. The shutoff valve consists of a housing, slide, two springs, two spring retainers, end cap, and an operating crank. The housing has two pressure outlet ports, both connected to the control valve; and a pressure inlet port and a return port, both connected to the main hydraulic system. The slide is maintained in the neutral (shutoff) position by the two springs that are installed on the slide between the two retainers. The retainers are positioned against steps in the housing and the end cap. The crank, attached to the end of the slide, is connected by mechanical linkage and cable system to the left longitudinal trim control handle. The lands on the slide are located so that when the crank is in the neutral (center) position,



HORIZONTAL STABILIZER DRIVE UNIT CONTROL VALVE

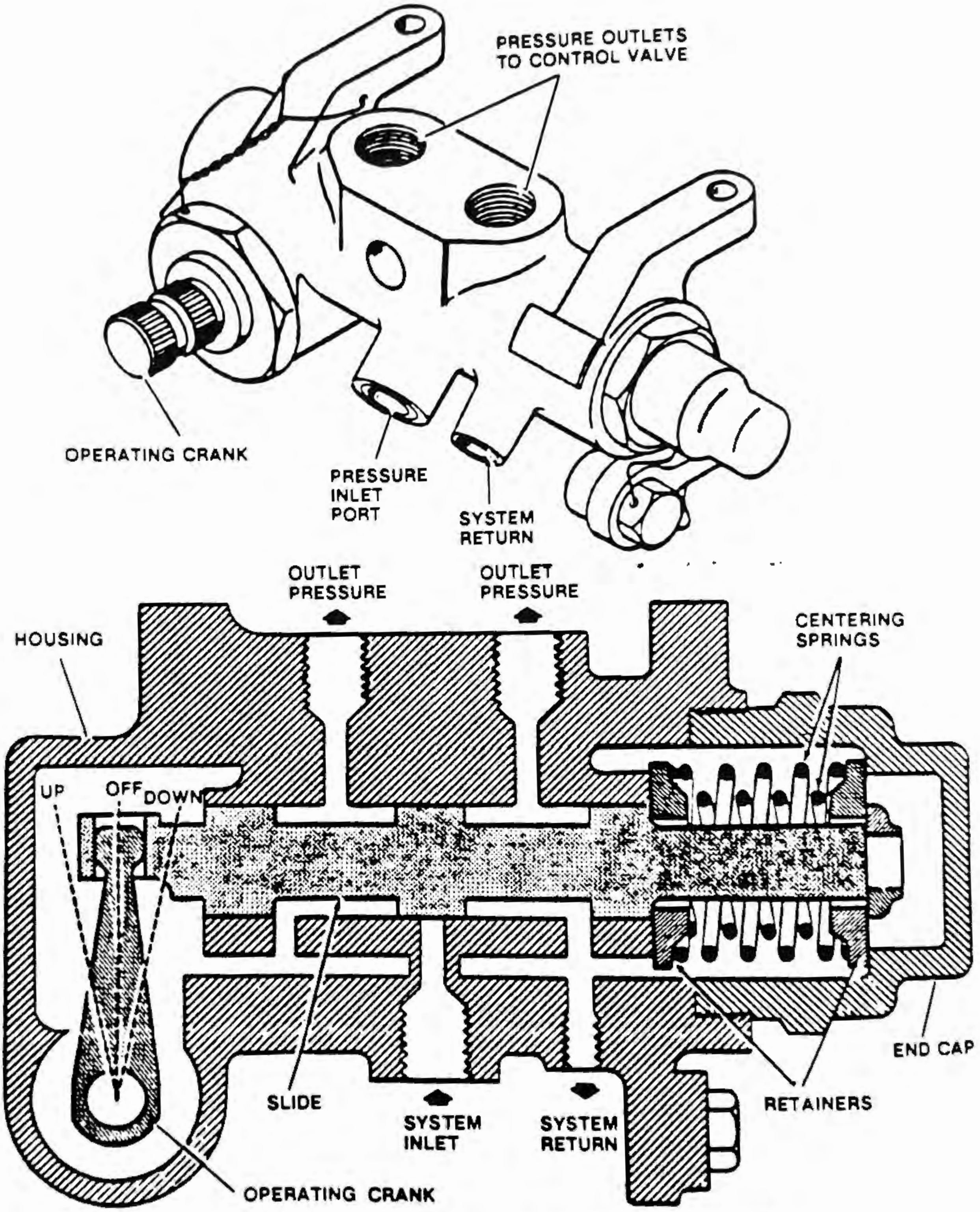
FTX80262

Figure 27-44

(b) The cable systems operate the valve cranks, which position the slides to open the applicable ports depending on the direction of stabilizer travel selected. The shutoff valve directs hydraulic pressure from the main hydraulic system to the control valve. The control valve directs the pressure to release the hydraulic brake and drive the hydraulic motor simultaneously. The hydraulic motor, through the brake torque shaft and the gearbox, rotates the drive sprocket clockwise or counterclockwise depending on the direction in which the control handles were moved. The drive sprocket drives the roller chains causing the jackscrew sprockets and nuts to rotate around the jackscrews. Since the nuts are mounted in bearings that are fixed to the structure, the jackscrews travel up or down within the nuts and move the horizontal stabilizer leading edge up or down. When the control handles are released, the spring-loaded slides in the control valve and shutoff valve return to the neutral positions and stabilizer motion is halted. If the stabilizer reaches the limit of travel before the control handles are released, the travel limit stops on the stabilizer forward spar will contact the travel limit stop arm, causing mechanical linkage to return the shutoff valve to the neutral position and halt stabilizer travel.

(2) Electric Control (See Figure 27-48)

(a) During electrical control of the longitudinal trim control system, operation of the system is the same as during manual control, except that the cable systems are electrically driven by two servo actuators. Clockwise or counterclockwise rotation of the actuators is controlled by the longitudinal trim dual slide button switches in each aileron control wheel. The actuator that drives the hydraulic shutoff valve cables is controlled by the left switch in each control wheel. the right switch in each control wheel controls the actuator that drives the hydraulic control valve cables. Both switches in one wheel must be moved simultaneously, in the same direction, to move the horizontal stabilizer.



HORIZONTAL STABILIZER DRIVE UNIT SHUTOFF VALVE

FTX80263

Figure 27-45

both outlet ports are closed. Moving the crank, in either direction from the neutral position, opens one outlet port to direct hydraulic pressure to the control valve. The shutoff valve crank is also connected by mechanical linkage to a travel limit stop arm that is actuated by stops on the horizontal stabilizer forward spar.

(3) Servo Actuators (See Figure 27-46)

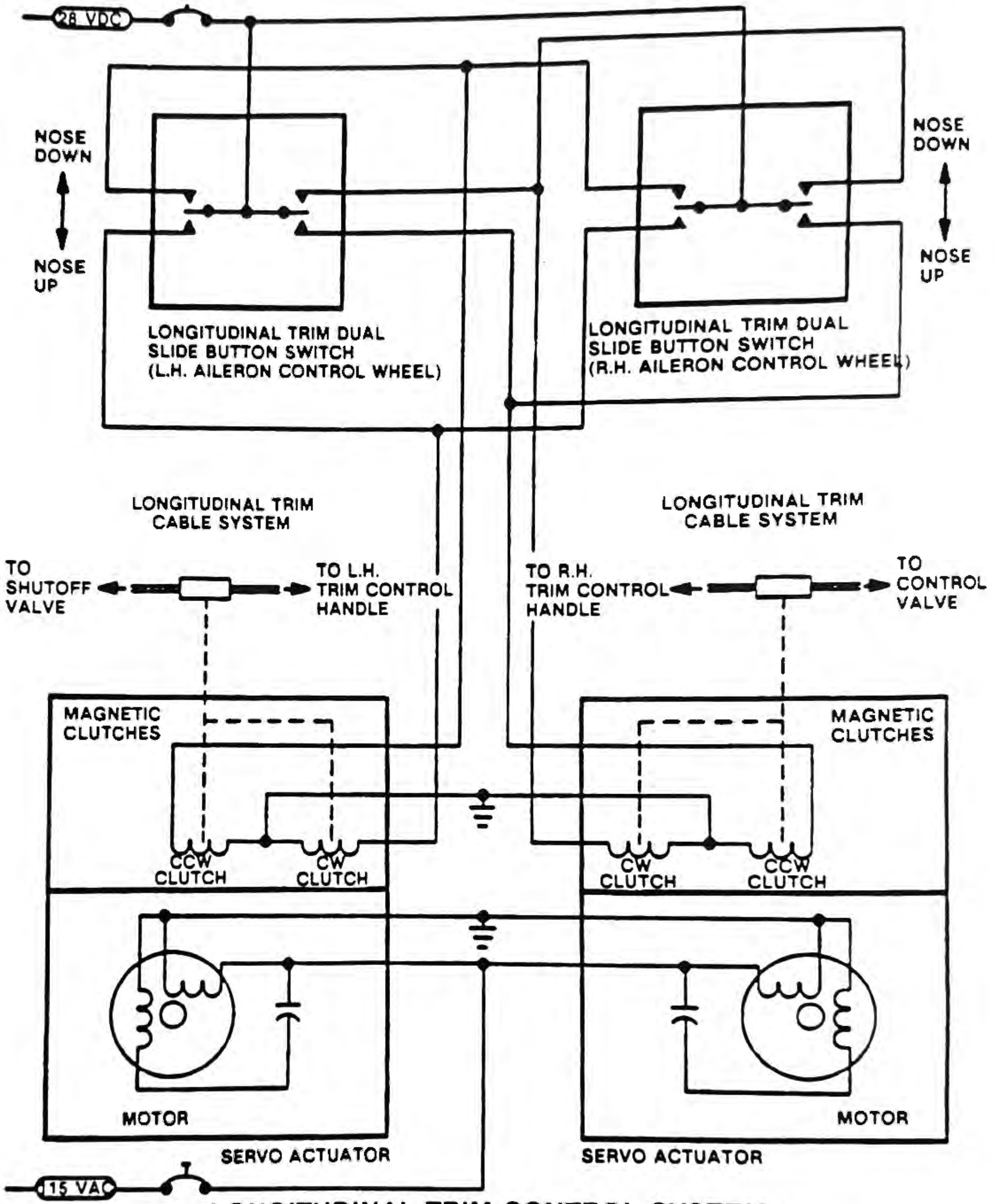
(a) Two servo actuators are located in the fuselage center section. One actuator, connected in the cable system between the right control handle and the hydraulic control valve, is electrically connected to the right slide button switch in each aileron control wheel. The other actuator connected in the cable system between the left control handle and the hydraulic shutoff valve, is electrically connected to the left slide button switch in each control wheel.

(b) Each actuator consists of an electric motor and two magnetic clutches in a common housing, and a drive crank. The clutches are geared to the motor output shaft so that they rotate in opposite directions. The output shaft of each clutch is connected by gears to the actuator output shaft. The drive crank, attached to the actuator output shaft, has a slotted end that fits over a ball fitting on the cable system. The motor, connected directly to the 115-vac electrical power supply, is running continuously. The clutches, electrically connected to the slide button switches, are normally disengaged.

C. Operation (See Figure 27-47)

(1) Manual Control

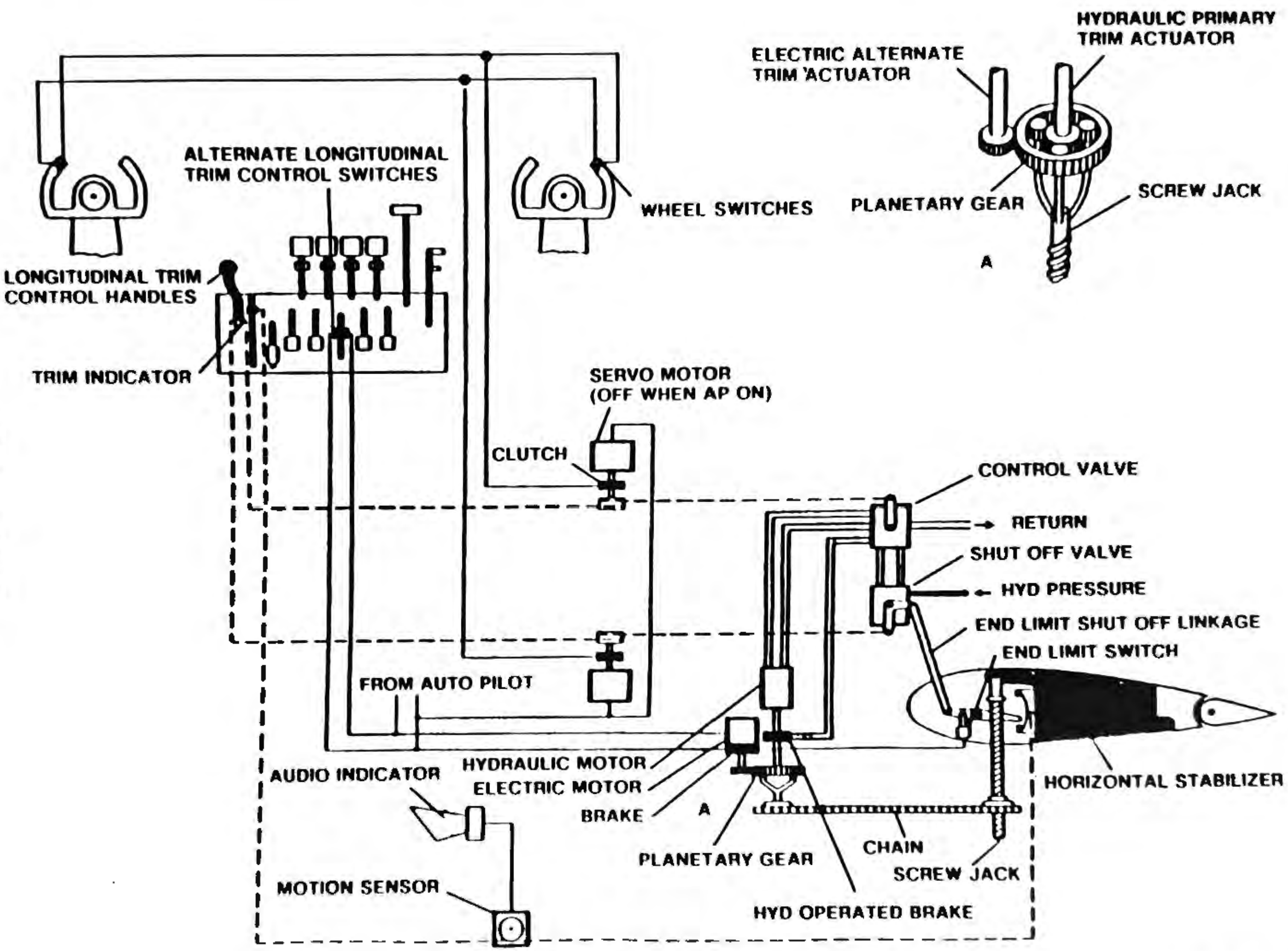
(a) Manual control is provided by the longitudinal trim control handles on the pilot's control pedestal. The right handle drives the cable system that operates the hydraulic control valve, and the left handle drives the cable system that operates the hydraulic shutoff valve. Since the valves are hydraulically connected in series, both control handles must be operated simultaneously in the same direction to move the stabilizer.


28 VDC
NOSE DOWN
NOSE UP
LONGITUDINAL TRIM DUAL SLIDE BUTTON SWITCH (L.H. AILERON CONTROL WHEEL)
NOSE DOWN
NOSE UP
LONGITUDINAL TRIM DUAL SLIDE BUTTON SWITCH (R.H. AILERON CONTROL WHEEL)
LONGITUDINAL TRIM CABLE SYSTEM
LONGITUDINAL TRIM CABLE SYSTEM
TO SHUTOFF VALVE
TO L.H. TRIM CONTROL HANDLE
TO R.H. TRIM CONTROL HANDLE
TO CONTROL VALVE
MAGNETIC CLUTCHES
MAGNETIC CLUTCHES
CCW CLUTCH
CW CLUTCH
CW CLUTCH
CCW CLUTCH
MOTOR
MOTOR
SERVO ACTUATOR
SERVO ACTUATOR
115 VAC

LONGITUDINAL TRIM CONTROL SYSTEM -- ELECTRICAL SCHEMATIC

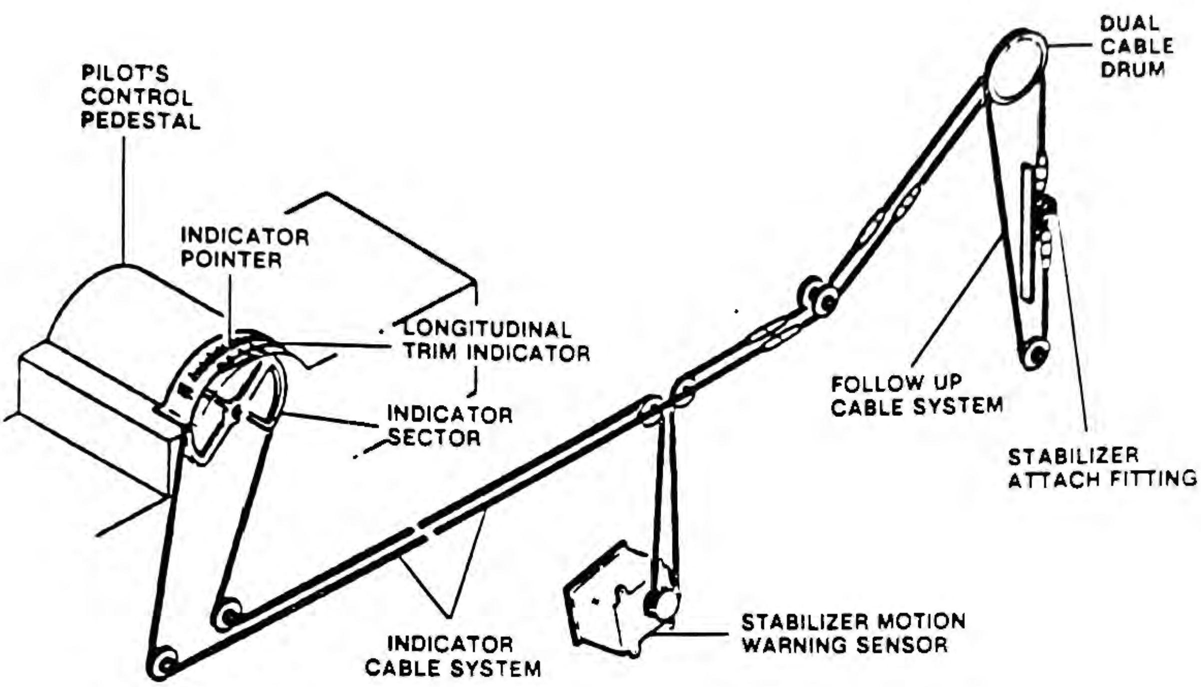
FTX80264

Figure 27-46

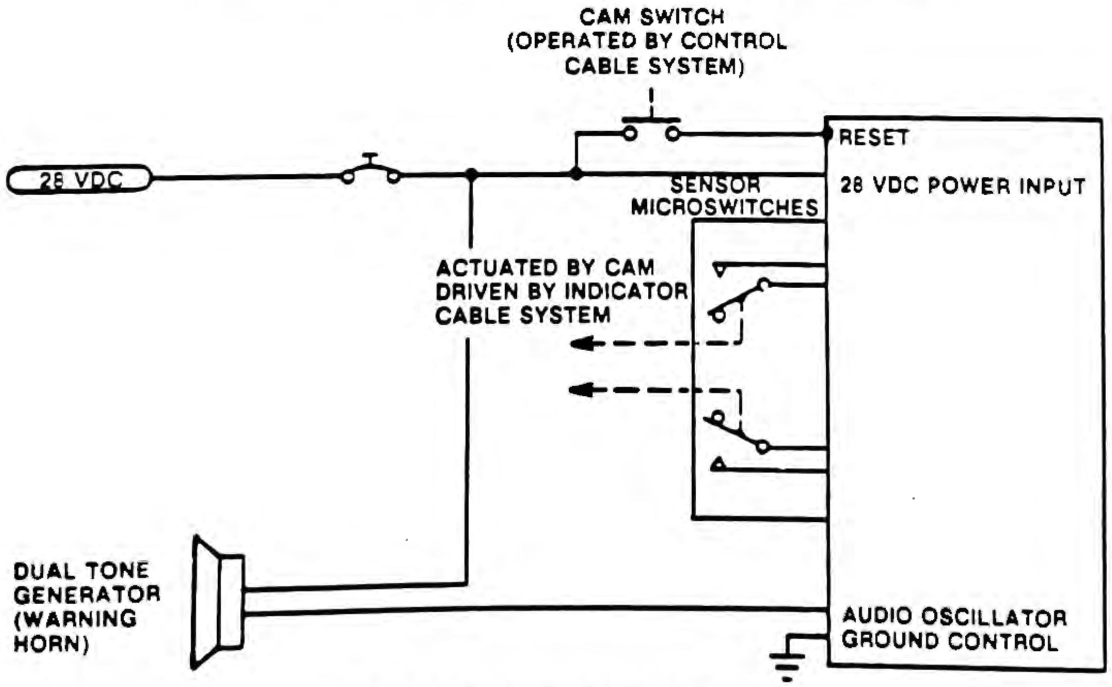


HORIZONTAL STABILIZER SCHEMATIC

Figure 27-47



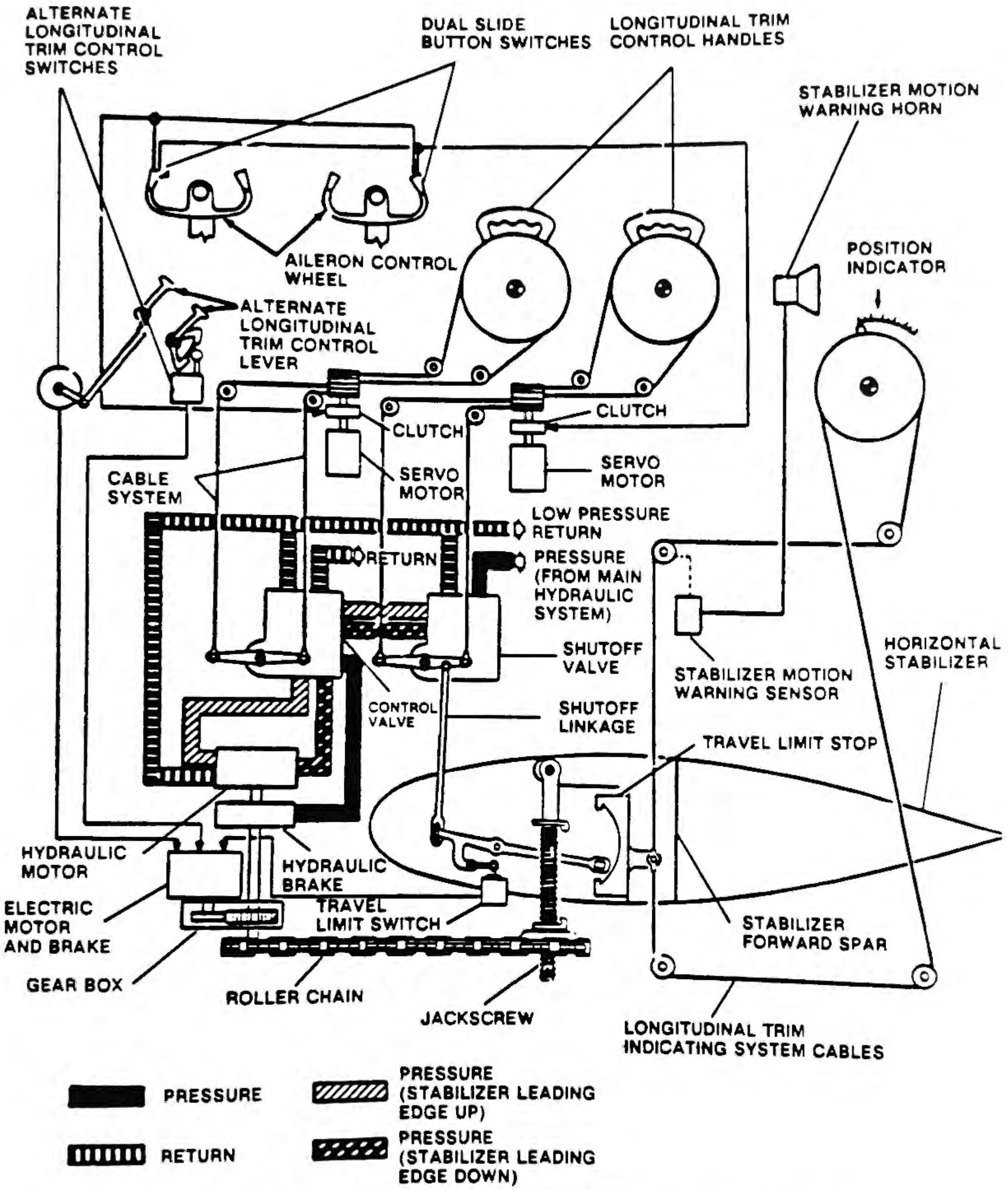
LONGITUDINAL TRIM INDICATING SYSTEM


CAM SWITCH (OPERATED BY CONTROL CABLE SYSTEM)
28 VDC
RESET
SENSOR MICROSWITCHES
28 VDC POWER INPUT
ACTUATED BY CAM DRIVEN BY INDICATOR CABLE SYSTEM
DUAL TONE GENERATOR (WARNING HORN)
AUDIO OSCILLATOR GROUND CONTROL

STABILIZER MOTION WARNING -- SCHEMATIC

FTX80266

Figure 27-50


ALTERNATE LONGITUDINAL TRIM CONTROL SWITCHES
DUAL SLIDE BUTTON SWITCHES
LONGITUDINAL TRIM CONTROL HANDLES
STABILIZER MOTION WARNING HORN
POSITION INDICATOR
AILERON CONTROL WHEEL
ALTERNATE LONGITUDINAL TRIM CONTROL LEVER
CLUTCH
CLUTCH
SERVO MOTOR
SERVO MOTOR
CABLE SYSTEM
LOW PRESSURE RETURN
RETURN
PRESSURE (FROM MAIN HYDRAULIC SYSTEM)
SHUTOFF VALVE
HORIZONTAL STABILIZER
STABILIZER MOTION WARNING SENSOR
CONTROL VALVE
SHUTOFF LINKAGE
TRAVEL LIMIT STOP
HYDRAULIC MOTOR
HYDRAULIC BRAKE
ELECTRIC MOTOR AND BRAKE
TRAVEL LIMIT SWITCH
STABILIZER FORWARD SPAR
GEAR BOX
ROLLER CHAIN
JACKSCREW
LONGITUDINAL TRIM INDICATING SYSTEM CABLES
PRESSURE
RETURN
PRESSURE (STABILIZER LEADING EDGE UP)
PRESSURE (STABILIZER LEADING EDGE DOWN)

HORIZONTAL STABILIZER SYSTEM -- SCHEMATIC FTX80254
Figure 27-48

(b) When both switches in one control wheel are moved in the same direction, 28-vdc circuits are completed to engage either the clockwise or counterclockwise magnetic clutch in each actuator. The clutches then act as couplings, transmitting torque from the output shafts of the continuous running electric motors to the actuator output shaft. The cranks, attached to the actuator output shafts, drive the cable systems to operate the shutoff valve and control valve. When the switches are released, the 28-vdc circuits are opened, the clutches are disengaged allowing the hydraulic valves to return to the neutral position, and stabilizer is halted.

14. Alternate Longitudinal Trim Control System - Description and Operation

A. General (See Figure 27-49)

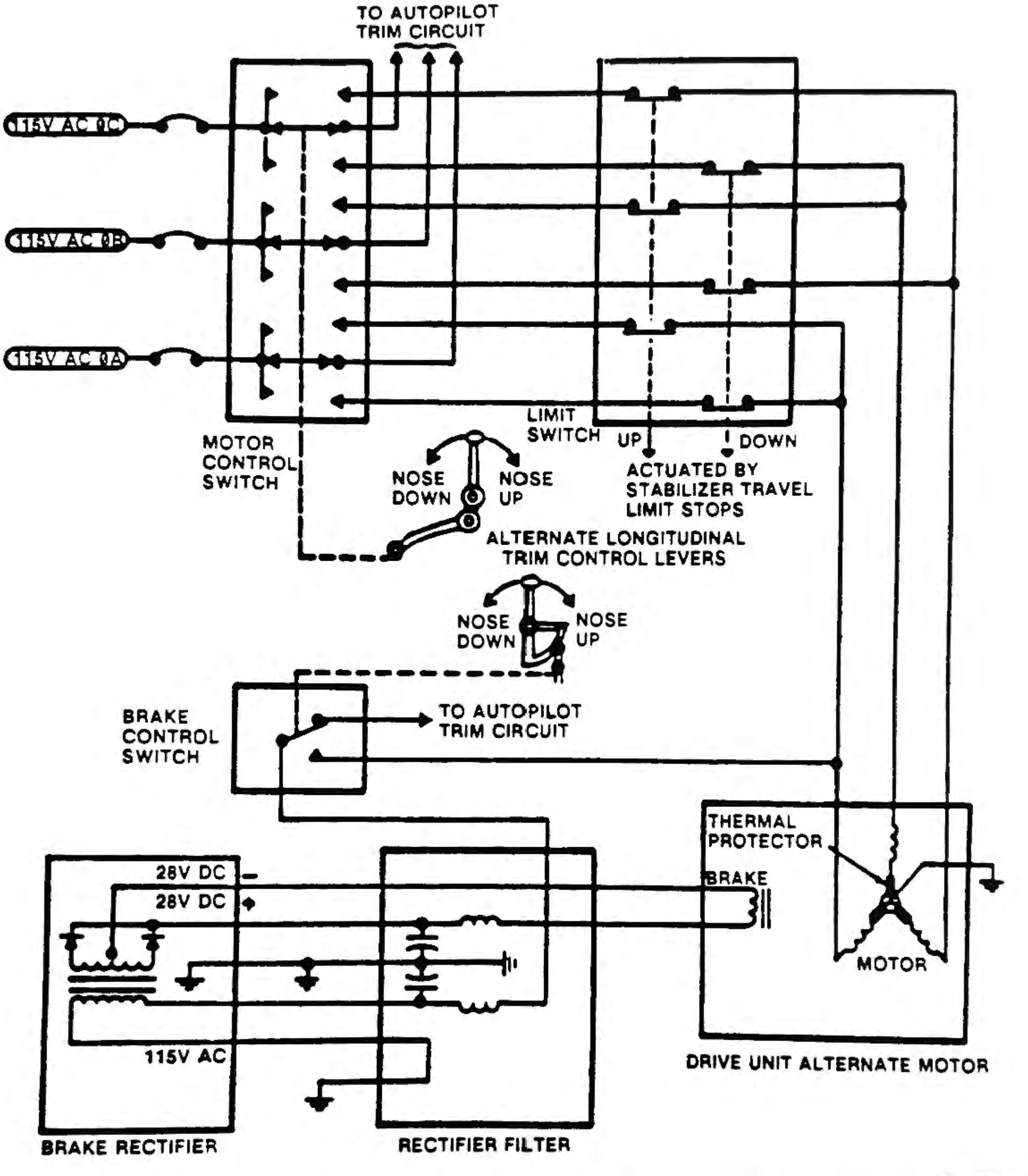
(1) The alternate longitudinal control system provides an alternate method of moving the horizontal stabilizer leading edge to obtain longitudinal trim. The alternate system uses an electric motor and brake to drive the same gearbox, roller chains, and jackscrews that move the stabilizer during control by the longitudinal trim control system.

(2) The alternate system is controlled by two control levers, located on the pilot's control pedestal, and consists of the control levers, two control switches, an electric motor and brake, brake rectifier, rectifier filter, and limit switch.

B. Component Description

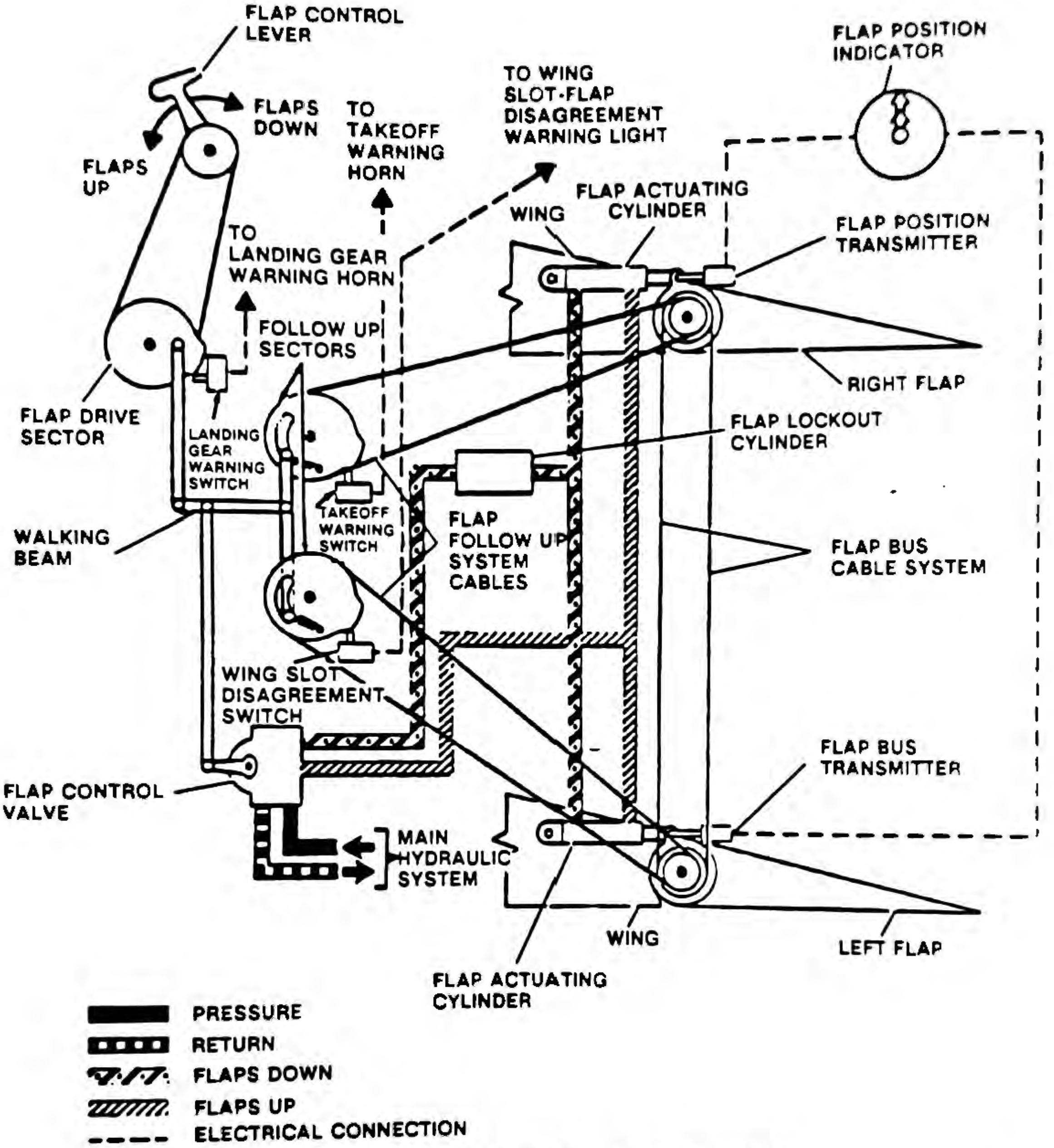
(1) Alternate Longitudinal Trim Control Switches

(a) Two alternate longitudinal trim control switches, a motor control switch, and a brake control switch, are located in the pilot's control pedestal. The motor control switch controls the 115-vac, 3-phase electrical power supply to the alternate longitudinal trim electric motor and brake. The switch is a 3-position rotary switch with three sets of contacts, electrically connected to the power supply and the autopilot trim relays, and through the limit switch contacts to the electric motor. A crank, attached to the switch



ALTERNATE LONGITUDINAL TRIM CONTROL SYSTEM -- SCHEMATIC

Figure 27-49



FLAP SYSTEMS -- SCHEMATIC

FTX80267

Figure 27-51

shaft, is connected by pushrod to the right control lever on the pedestal. The switch is mounted on a channel attached to the forward end of the pedestal frame.

(b) The brake control switch controls the 115-vac electrical power supply to the brake rectifier and filter. The switch is a 2-position switch electrically connected through the limit switch and motor control switch contacts to one phase of the 115-vac electrical power supply, to the brake rectifier filter, and to the autopilot trim circuit. A roller-type actuator on the switch is actuated by a cam attached to the left control lever on the pedestal. The switch is mounted on a bracket attached to the pedestal frame below the control lever.

(2) Electric Motor and Brake

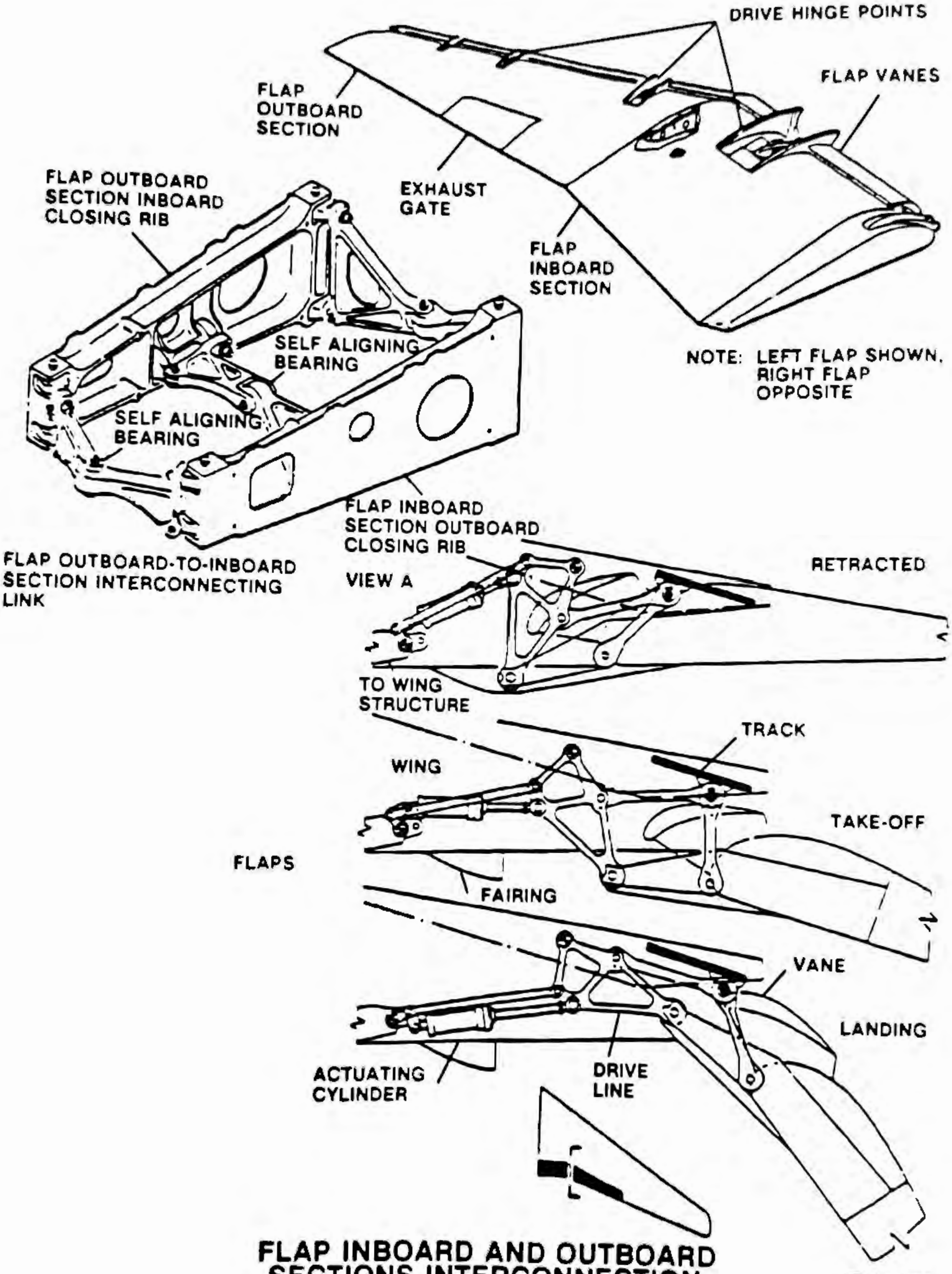
(a) The electric motor is a fan-cooled, 3-phase, 115-vac, 400-cycle. reversible motor with a 28-vdc brake and a thermal protector. The motor is mounted on the horizontal stabilizer drive unit, with the motor output shaft engaged in the first-stage gears in the gearbox.

(b) The motor is electrically connected through the limit switch contacts to the motor control switch and the autopilot trim relays. The brake coil in the motor is electrically connected through a filter to the brake rectifier.

(3) Brake Rectifier and Filter

(a) The brake rectifier and filter act as a dc electrical power supply, converting 115-vac, 400-cycle, single-phase input voltage to 28-vdc output voltage, which is used to energize the brake coil in the electric motor.

(b) The rectifier consists of a stepdown transformer and two rectifier diodes in a sealed housing. The filter, in a separate housing, consists of two air core coils and two capacitors. The primary winding of the transformer is electrically connected through the filter to the brake control switch and to ground. The secondary winding is connected through the filter to the brake coil in the electric motor. Both the rectifier and filter are mounted on a bracket attached to the horizontal stabilizer drive unit.



FLAP INBOARD AND OUTBOARD SECTIONS INTERCONNECTION

Figure 27-52

(4) Limit Switch

(a) The limit switch provides automatic shutoff control for the alternate system when the horizontal stabilizer reaches the limits of travel. The limit switch is mounted on a bracket attached to the horizontal stabilizer drive unit.

(b) The limit switch has two sets of normally closed contacts. One set of contacts limits the upward travel of the stabilizer, and the other sets limits the downward travel of the stabilizer. An actuator on the switch is mechanically connected to a travel limit stop arm that is actuated by travel limits stops on the stabilizer forward spar. Electrically, the switch is connected to the motor control switch, the electric motor, the brake control switch, and the autopilot trim relays.

C. Operation

(1) When the alternate longitudinal trim control levers are in the neutral (center) position, the motor and brake control switches are included in the autopilot trim circuit. No action occurs unless the autopilot relays are energized. To obtain longitudinal trim with the alternate system, both control levers must be operated simultaneously.

(2) Moving both control levers in either direction from the neutral position disengages the autopilot trim circuit and completes a 115-vac, 3-phase circuit from the motor control switch, through the limit switch, to the electric motor. At the same time, a 115-vac, single-phase circuit is completed from the motor control switch, through the limit switch and brake switch contacts, to the brake rectifier and filter. The rectifier steps down and rectifies the input voltage to induce a 28-vdc circuit through the filter to energize the brake coil and release the brake, allowing the electric motor output shaft to rotate. The motor drives the gearbox, roller chains, and jackscrews to move the stabilizer up or down.

(3) When the control levers are released, the control switches return to the neutral positions, the circuit to the brake and motor is opened, and stabilizer motion is halted. If the stabilizer reaches the limit of travel before the switches are released, the stabilizer travel limit stops contact the travel limit arm. The travel limit arm moves mechanical

linkage to actuate the limit switch. The normally closed contacts in the limit switch open, interrupting the 115-vac circuit to the brake and motor and halting stabilizer motion.

15. Longitudinal Trim Indicating and Stabilizer Motion Warning System - Description and Operation

A. General (See Figure 27-50)

(1) The longitudinal trim indicating and stabilizer motion warning system is a mechanical system that indicates the position of the horizontal stabilizer and provides an audible warning when the stabilizer is in motion. The system consists of an indicator scale, indicator sector and pointer, indicating cable system, follow-up cable system, stabilizer motion warning sensor, and a dual tone generator.

(2) The indicator scale is a slotted panel attached to the pilot's control pedestal adjacent to the longitudinal trim control handles. The scale is graduated in degrees noseup or nosedown from the neutral (zero degrees) position. The indicator sector, located in the pedestal, has a pointer that protrudes through the slot in the scale.

(3) The indicating cable system is routed from the sector, through the flight compartment floor and the fuselage, to a dual drum assembly in the fuselage tail section. The drum assembly consists of a small drum and a large drum mounted on the fuselage structure. The indicating cable is routed around the small drum. The follow-up cable system is routed around the large drum and a pulley lower in the tail section. One side of the follow-up cable is attached to a bracket mounted on the horizontal stabilizer forward spar.

(4) The stabilizer motion warning sensor, located in the fuselage center section, is an electrical device consisting of an electronic circuit in a housing, two sprockets and shafts, a roller chain, cam, and two microswitches. The housing is installed on two brackets attached to the fuselage structure. The cam and small sprocket are mounted on a shaft that extends from the side of the housing. The large sprocket is mounted on a splined drive shaft extending from the housing. The splined portion of the drive shaft fits inside the hub of a pulley, which is driven by a loop in the indicating cable system. The two microswitches are positioned on the housing so that the corners of the square cam contact the switch actuators when the cam is rotated. The

switches are electrically connected to the oscillator circuit within the housing. The oscillator is electrically connected to the 28-vdc power system and the dual tone generator.

(5) The dual tone generator, located on the main instrument panel in the flight compartment, consists of a speaker and a signal generating circuit within a cover. A perforated plate, attached to the cover, acts as a speaker grille.

B. Operation

(1) When the horizontal stabilizer is being moved by either control system, the follow-up cable system is driven by the bracket on the stabilizer forward spar. The dual drum assembly is rotated, driving the indicator cable system that rotates the sector in the pilot's control pedestal. The indicator pointer, attached to the sector, moves in the slot of the indicator scale to show the position of the stabilizer in degrees airplane noseup (stabilizer leading edge down) or degrees airplane nosedown (stabilizer leading edge up).

(2) As the indicator cables move, a loop in the cable system drives a pulley that rotates the cam on the stabilizer motion warning sensor. The corners on the square cam operate the microswitch actuators alternately (one switch is actuated each 45 degrees of cam rotation). The oscillator circuit in the sensor is maintained in the stable condition (no signal at the output). Actuating the microswitches provides the electrical pulses required to operate the oscillator circuit and provide a signal that is transmitted to the dual tone generator. The dual tone generator (warning horn) receives the signal and converts it to a dual tone audible warning signal, which is heard through the speaker. The stabilizer motion warning is sounded once for approximately each half degree of stabilizer travel. A cam switch, operated by the trim control cable system, resets the motion warning sensor to prevent audible warning during all modes of longitudinal trim of less than one half degree.

16. Flaps - Description and Operation

A. General

(1) The flaps are movable surfaces that are extended during takeoff to increase lift, or during the landing approach and rollout to increase drag and reduce the speed of the airplane. The flap system consists of the flap control system, the flap warning system, and the flap position indicating system.

(2) The flap control system is a mechanically controlled, hydraulically actuated system that controls the extension and retraction of the flaps. Two subsystems combine to control the movement and positioning of the flaps. An actuating system, operated by a lever on the pilot's control pedestal, moves the flaps. A follow-up system, driven by movement of the flaps, halts further movement when the flaps have reached the selected position. A third subsystem, the flap bus system maintains symmetrical extension and retraction of the flap throughout the operating range.

(3) The flap warning system is a mechanically actuated electrical system consisting of a wing slot -- flap disagreement indication system, flap landing gear warning system, and a flap takeoff warning system. The wing slot -- flap disagreement indicating system will cause a warning light in the flight compartment to come on if the flaps are fully retracted and the wing slots are not fully closed, or if the flaps are extended and the wind slots are not open. The landing gear warning systems will provide an audible warning if the engine throttles are retarded for landing with the flaps extended 10 degrees or more and the landing gear is not down and latched. The takeoff warning system will sound an audible warning if the throttles are advanced while the airplane is on the ground and the flaps are not properly positioned for takeoff.

(4) The flap position indicating system is a mechanically actuated electrical system that transmits the position of the left and right flaps to a dual indicator on the first officer's instrument panel in the flight compartment. The dual indicator pointers are designed so that they clearly show any mismatch between the left and right flaps.

17. Flap Control System - Description and Operation

A. General (See Figure 27-51)

(1) The flap control system is a hydraulically actuated, mechanically controlled system that controls the operation of the flaps. The system consists of an actuating system, follow-up system, and a flap bus system. The actuating system initiates the movement of the flaps and the follow-up system halts the movement when the flaps have reached the selected position. The flap bus system maintains symmetrical movement of the left and right flaps throughout the operating range. The flap control system consists of the follow major components:

Component	**Location**
Two flaps	One hinged to rear spar of each wing, inboard of ailerons
Control	On pilot's control pedestal in flight compartment
Drive sector, flap control valve, follow-up sectors, and walking beam	In right main wheel well
Three flap lockout, cylinders, two balanced relief valves, and two bleeder valve manifolds	In left main wheel well
Six flap actuating cylinders	Three attached to each wing rear spar, forward of flap drive hinges
Thermal relief valve	In right wing root
Flap bus cable drums	One in each main wheel well

(2) The control lever is attached to a sector mounted on the main lever shaft of the pilot's control pedestal. The sector is connected by a two-way cable system, routed through the flight compartment floor and the fuselage, to the drive sector. A link connects the drive sector to the upper end of the walking beam. A pushrod, attached midway along the beam, is connected to the flap control valve operating crank. The lower end of the walking beam is connected to a crank located between the two follow-up sectors. A crosspin, installed through the crank, is held by springs against the forward edge of a slot in each

follow-up sector. Each follow-up sector is connected by a two-way cable system and mechanical linkage to the center hinge of the corresponding (left or right) flap.

(3) Each flap bus cable drum is mounted on the inboard end of a torque tube that is installed through the outboard bulkhead of the wheel well. An arm on the outboard end of the torque tube is connected by a link to the adjacent flap inboard hinge. A two-way cable system, routed across the ceiling of the two wheel wells, interconnects the two cable drums. A bridle cable system, connected to the bus cable system in the right wheel well, operates the rudder throw-limiting and pressure reducing components.

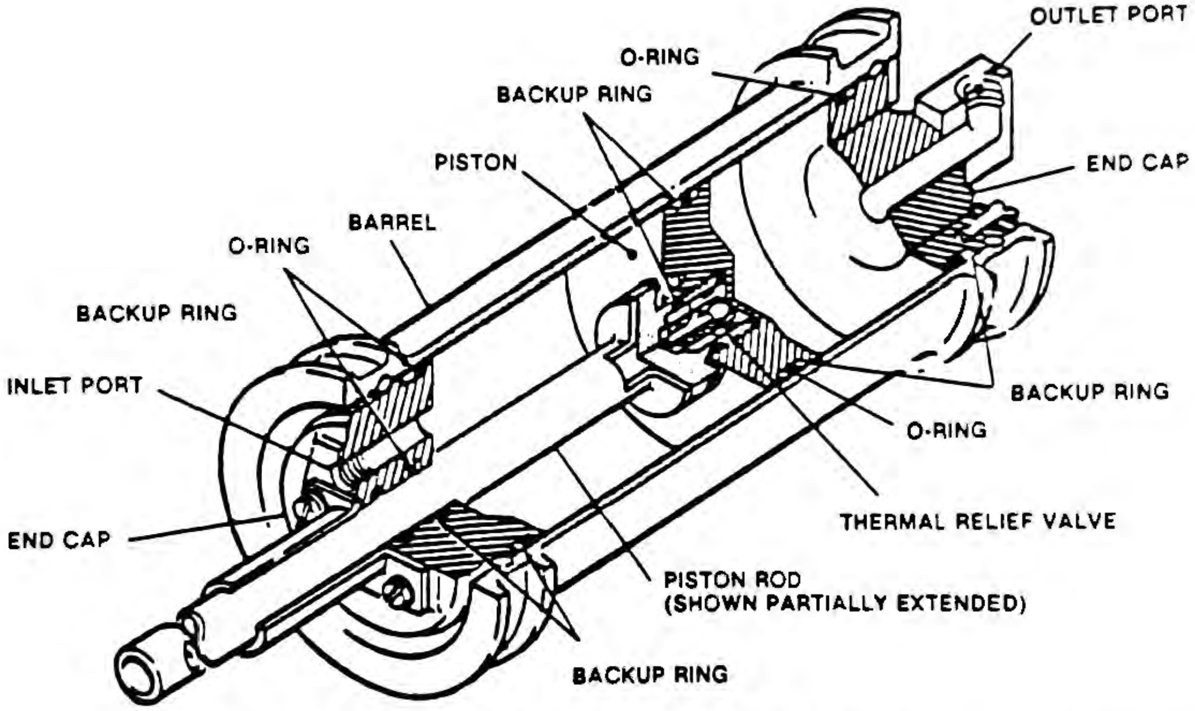
B. Component Description

(1) Flaps (See Figure 27-52 & 27-53)

(a) Due to the wing sweepback, each flap is divided into two sections. The sections are interconnected by linkage that permits movement in two planes, and also provides simultaneous extension or retraction of the two sections. Fixed vanes, attached to the leading edge of each section, provide more efficient airstreaming when the flaps are extended. The vanes are removable without removing the flaps from the airplane.

(b) The inboard section of each flap is attached to the wing rear spar at two hinge points. The outboard hinge is the drive hinge, connected by mechanical linkage to the flap inboard actuating cylinder.

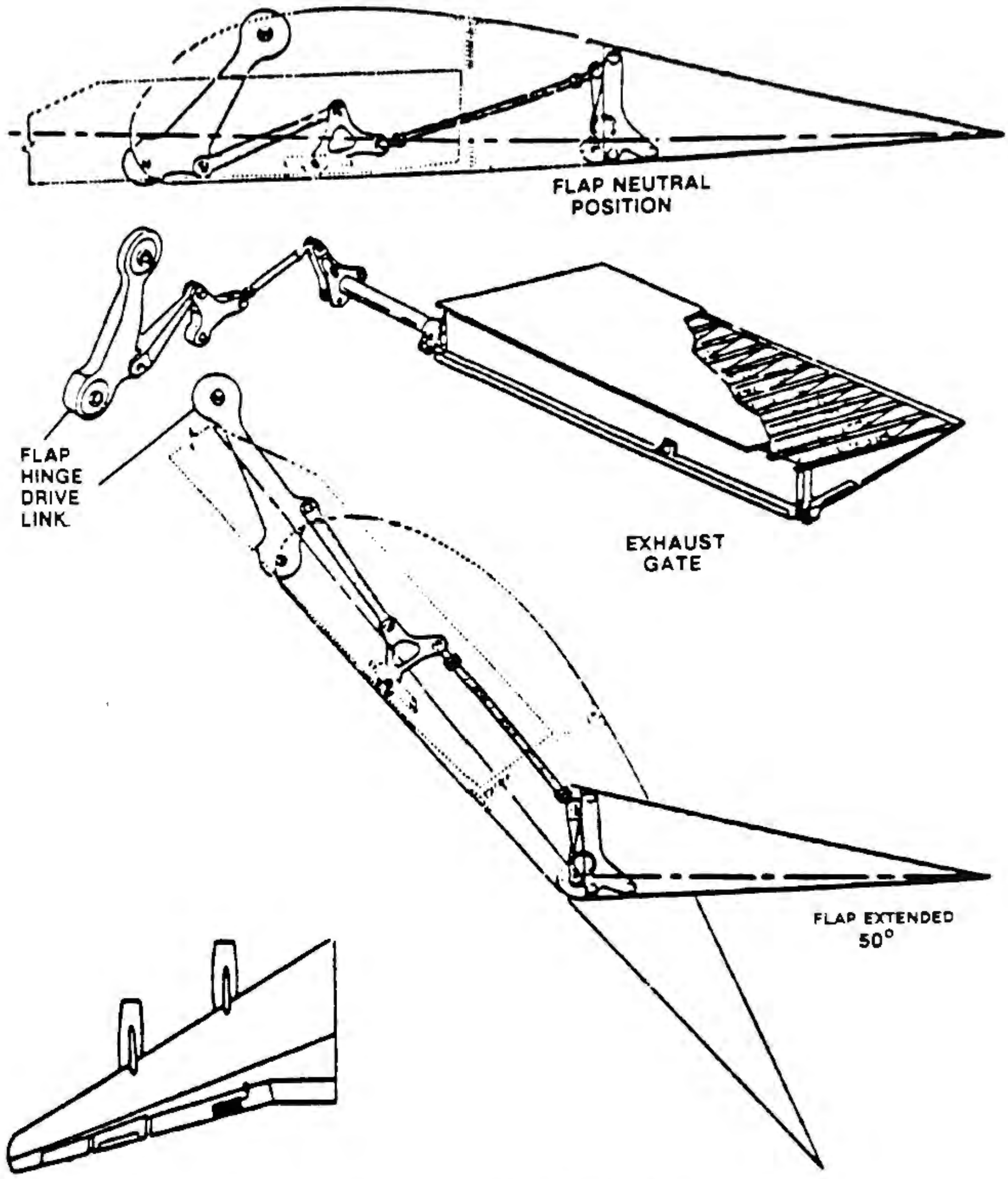
(c) The outboard section of each flap is attached to the wing rear spar at three hinge points. The inboard and center hinges are the drive hinges, connected by mechanical linkage to the midwing and outboard flap actuating cylinders. An exhaust gate is hinged to the rear spar of each outboard section directly behind the inboard engine. Mechanical linkage connects the gate to the mid-wing drive hinge so that as the flaps extend, the gate is positioned parallel to and above the engine exhaust path, permitting passage of the exhaust gases.



FLAP LOCKOUT CYLINDER -- CUTAWAY

FTX80300

Figure 27-56



OUTBOARD FLAP EXHAUST GATE AND LINKAGE FTX80268

Figure 27-53

(2) Flap Control Valve (See Figure 27-54)

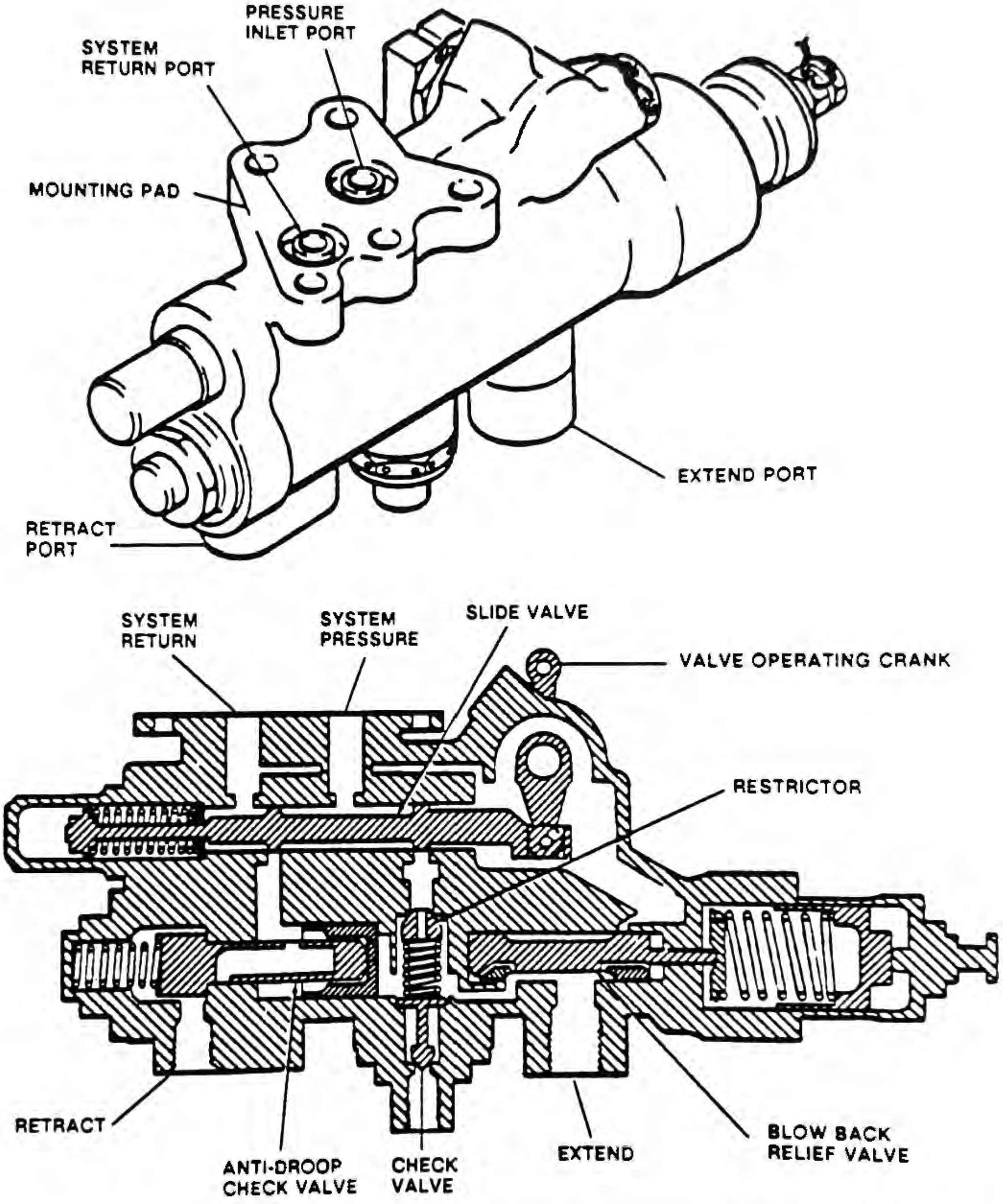
(a) The flap control valve, located on the right hydraulic power manifold in the right main wheel well, controls the supply of hydraulic pressure to the flap actuating cylinders. The control valve consists of a manually operated slide valve, a blowback relief valve, one-way restrictor valve, and a check valve in one housing.

(b) The control valve is hydraulically connected through the flap lockout cylinders to the extend (flaps down) side of the actuating cylinders, to the retract (flaps up) side of the midwing and inboard actuating cylinders, and to the main hydraulic system pressure and return lines. The slide valve operating crank is connected by pushrod to the walking beam.

(3) Flap Actuating Cylinders (See Figure 27-55)

(a) The flap actuating cylinders, three on each wing, are operated by hydraulic pressure to extend or retract the flaps. The actuating cylinders are hydraulically connected in pairs: each cylinder is connected in parallel with the corresponding cylinder on the opposite wing. Each cylinder consists of a body and a piston. The forward end of each actuator cylinder body is attached to the wing structure. The piston of each inboard actuating cylinder is connected to the drive linkage of the flap inboard section. The pistons of the midwing and outboard actuating cylinders are connected to the drive linkage of the flap outboard section.

(b) The extend port on each midwing and inboard actuating cylinder is hydraulically connected through a balanced relief valve to the corresponding (midwing or inboard) flap lockout cylinder. The retract ports are connected to the flap control valve. The extend port on each outboard actuating cylinder is connected to the outboard flap lockout cylinder, and the retract port is connected to the corresponding (left or right) engine-driven pump suction line.



FLAP CONTROL VALVE -- SCHEMATIC

FTX80272

Figure 27-54

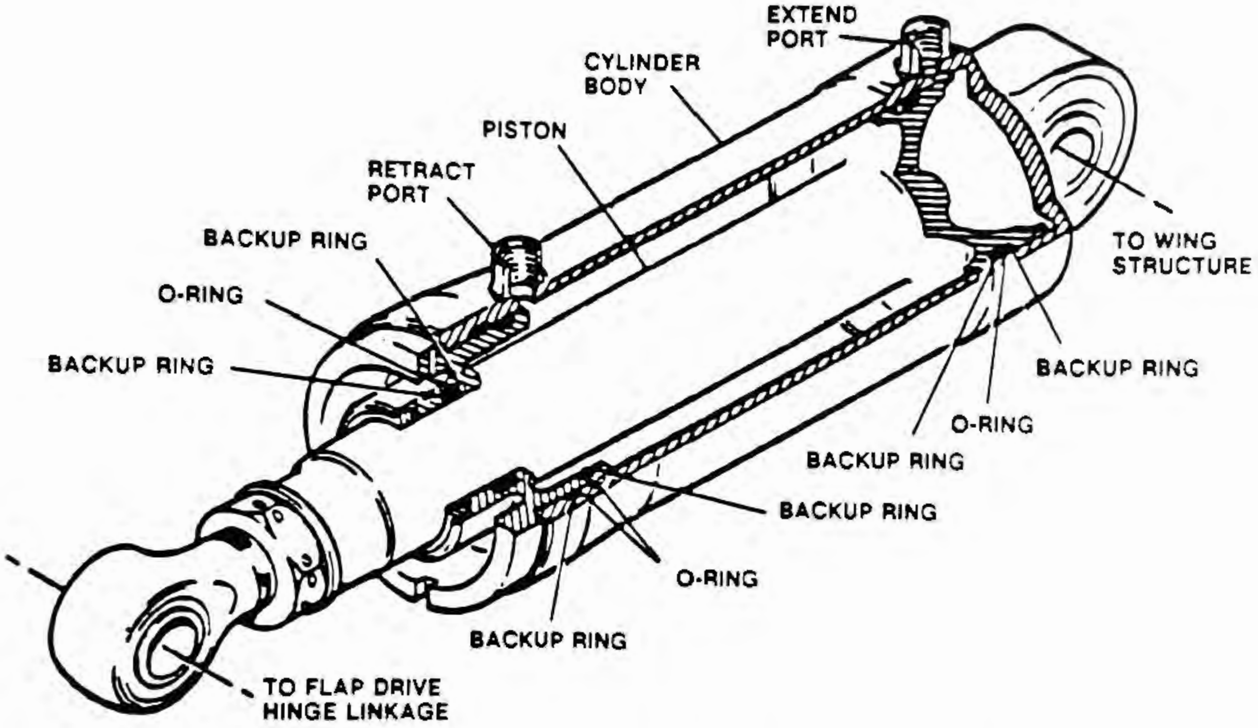
(b) There are five one-way check valves in the system. One check valve, located between each lockout cylinder and its bleeder valve on the lockout cylinder manifold, prevents fluid from entering the bleeder valve from the cylinder. A fourth check valve, located in the line between the extend port of the control valve and the actuating cylinder bleeder valve manifold, prevents fluid from entering the bleeder valves directly from the control valve. The fifth check valve, installed in the pressure line from the main hydraulic system to the control valve, permits fluid to enter the valve only.

(c) Five restrictor valves govern the rate of fluid flow in the system. Three one-way restrictor valves, one in the pressure line between each lockout cylinder and the control valve, restrict the fluid flow into the cylinder and allow free flow from the cylinder to the control valve. Another one-way restrictor valve, downstream of the control valve extend port, allows free flow of fluid into the control valve extend port, and restricts the flow from the valve. A two-way restrictor valve, installed downstream of the control valve retract port, restricts fluid flow to and from the control valve.

C. Operation

(1) Mechanical Linkage (See Figures 27-59 & 27-60)

(a) When the flap control lever is moved, the cable system rotates the drive sector, causing the walking beam to move. The pushrod from the walking beam positions the flap control valve slide to direct hydraulic pressure to extend or retract the flap actuating cylinders, causing the flap drive linkages to extend or retract the flaps.



FLAP ACTUATING CYLINDER -- CUTAWAY

FTX80301

Figure 27-55

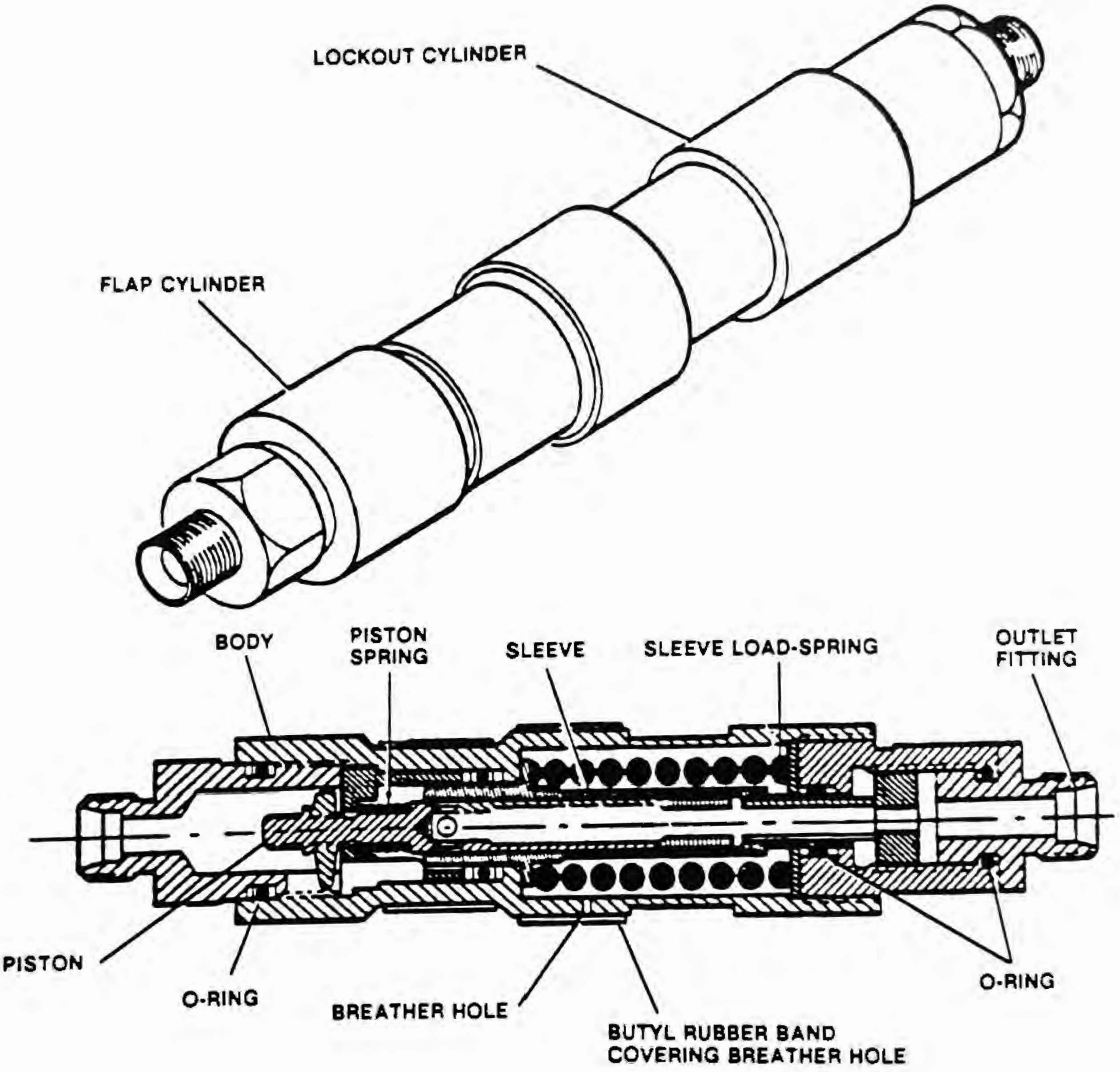
(4) Flap Lockout Cylinders (See Figure 27-56)

(a) There are three flap lockout cylinders mounted on the inboard bulkhead of the left main wheel well. Each lockout cylinder isolates one pair of actuating cylinders from the main hydraulic system to prevent total loss of hydraulic pressure due to damage or leakage downstream of the lockout cylinders. A thermal relief valve is incorporated into each lockout cylinder to relieve excessive pressure such as that caused by thermal expansion. Each lockout cylinder consists of a barrel, two end caps, a piston, and the thermal relief valve.

(b) The inlet ports on all three lockout cylinders are hydraulically connected through a restrictor valve to the flap control valve. The restrictor valve allows free flow from the cylinder but restricts the flow into the cylinder. The outlet ports on the midwing and inboard lockout cylinders are connected to a balanced relief valve. The outlet port on the outboard lockout cylinder is connected to the two outboard actuating cylinders.

(5) Flap Balanced Relief Valve (See Figure 27-57)

(a) There are two balanced relief valves mounted on the inboard bulkhead of the left main wheel well. In the event of a sudden loss of hydraulic pressure when the flaps are extended, the relief valves trap fluid in the extend side of the actuating cylinders, thus preventing rapid upward movement of the flaps due to airload. One relief valve is located in the system between the midwing lockout cylinder and the two midwing actuating cylinders. The other relief valve is located between the inboard lockout cylinder and the two inboard actuating cylinders. Each relief valve consists of a body, piston, piston spring, sleeve, sleeve spring, and two outlet fittings. Markings on the body identify the outlets as flap cylinder and lockout cylinder.



FLAP BALANCED RELIEF VALVE -- SCHEMATIC

FTX80273

Figure 27-57

(b) When the flap control valve is in the extended position, hydraulic fluid is allowed to flow freely through the balanced relief valves to the extend side of the actuating cylinders. When the control valve slide is moved to the retract position, hydraulic pressure returning from the extend side of the actuating cylinders moves each relief valve piston causing the piston spring to compress. When the piston spring is fully compressed, the piston moves the sleeve and opens passages to allow the fluid to flow through the relief valve to the lockout cylinder. Tension of the sleeve spring is set so that no more than 1775 psi is required to open the valve. If hydraulic pressure drops to approximately 1475 psi while the flaps are in the extended position, tension on the sleeve spring will reseat the sleeve, preventing fluid from entering the relief valve from the actuating cylinder extend lines.

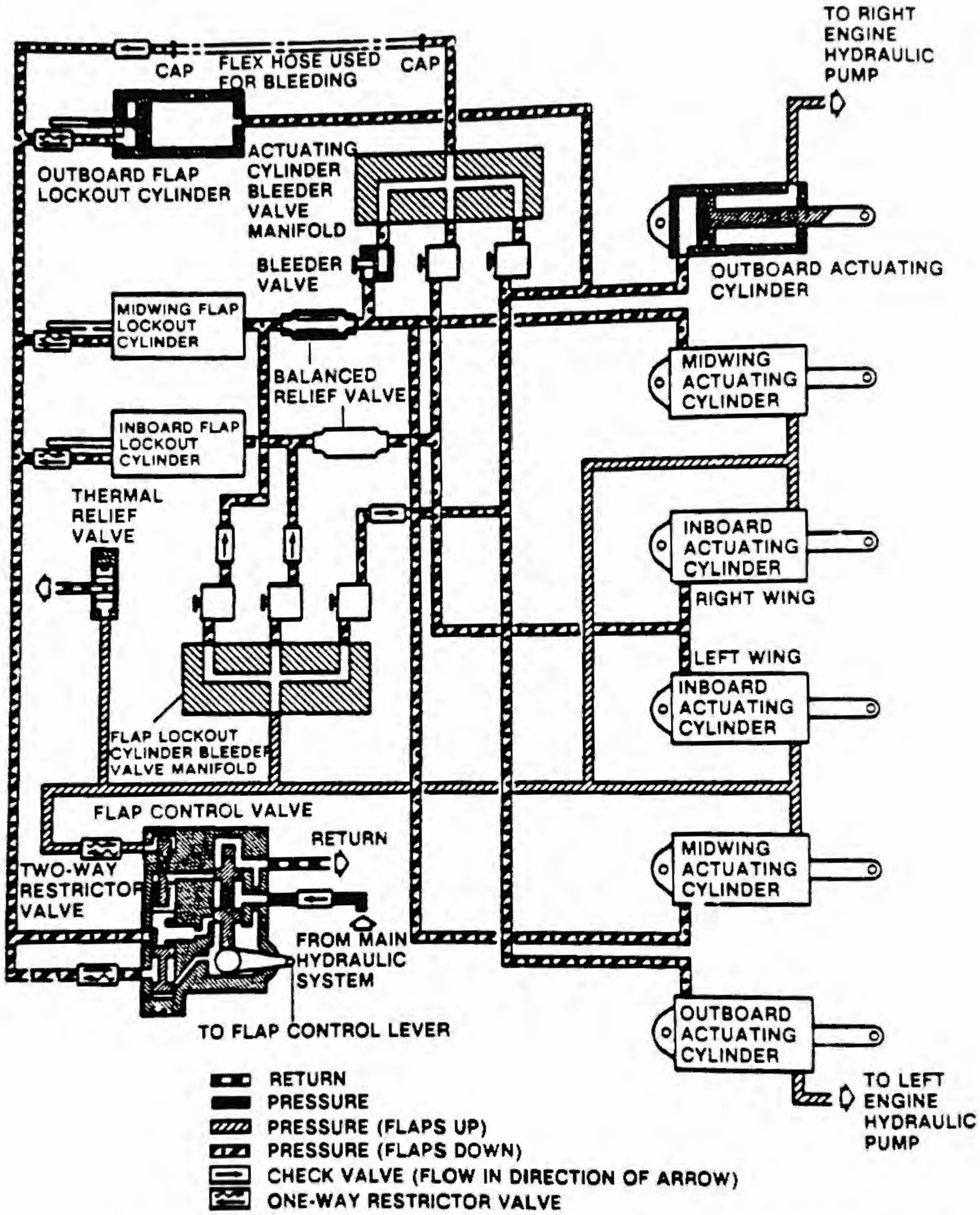
(6) Flap Thermal Relief Valve (See Figure 27-58)

(a) The thermal relief valve relieves excessive hydraulic pressure, such as that caused by thermal expansion, from the actuating cylinders. The valve consists of a housing and a spring-loaded poppet-type valve. The inlet port is connected to a T-fitting in the pressure line between the control valve retract port and the actuating cylinders. The outlet port is connected to the system return line.

(b) If the hydraulic pressure entering the valve increases above approximately 3300 psi, the spring-loaded poppet is unseated, allowing the excessive pressure to escape to the system return line. The poppet is reseated at 100 psi below the actual pressure that opens the valve.

(7) Bleeder Valves, Check Valves, and Restrictor Valves

(a) Six bleeder valves are provided in the system for the purpose of filling and bleeding the lockout cylinders. The actuating cylinder and the lockout cylinder bleeder valve manifolds each have three bleeder valves. One valve on each manifold is connected between each lockout cylinder and pair of actuating cylinders. The valves on the lockout cylinder manifold are used to fill the lockout cylinders. The valves on the actuating cylinder manifold are used to bleed the cylinders.


CAP
FLEX HOSE USED FOR BLEEDING
CAP
TO RIGHT ENGINE HYDRAULIC PUMP
OUTBOARD FLAP LOCKOUT CYLINDER
ACTUATING CYLINDER BLEEDER VALVE MANIFOLD
BLEEDER VALVE
OUTBOARD ACTUATING CYLINDER
MIDWING FLAP LOCKOUT CYLINDER
BALANCED RELIEF VALVE
MIDWING ACTUATING CYLINDER
INBOARD FLAP LOCKOUT CYLINDER
THERMAL RELIEF VALVE
INBOARD ACTUATING CYLINDER
RIGHT WING
LEFT WING
INBOARD ACTUATING CYLINDER
FLAP LOCKOUT CYLINDER BLEEDER VALVE MANIFOLD
FLAP CONTROL VALVE
RETURN
TWO-WAY RESTRICTOR VALVE
MIDWING ACTUATING CYLINDER
FROM MAIN HYDRAULIC SYSTEM
TO FLAP CONTROL LEVER
OUTBOARD ACTUATING CYLINDER
TO LEFT ENGINE HYDRAULIC PUMP
RETURN
PRESSURE
PRESSURE (FLAPS UP)
PRESSURE (FLAPS DOWN)
CHECK VALVE (FLOW IN DIRECTION OF ARROW)
ONE-WAY RESTRICTOR VALVE

FLAP CONTROL SYSTEM -- HYDRAULIC SCHEMATIC FTX80274

Figure 27-58

(e) Check extension of lockout cylinder piston rod against dimension in step b.

1 If lockout cylinder piston rod has moved more than 3/8 inch from position recorded, excessive air is in the system and lockout cylinder should be bled.

(3) Move flap control lever to full down position and re-connect pushrod to operating crank.

C. Bleed Lockout Cylinder

(1) Depressurize main hydraulic system and relieve pressure from hydraulic reservoir.

(a) Remove caps from down line bleed connection and actuating cylinder port.

(b) Connect flexible hose, suitable for 3000 psi pressure, between down-line connections and actuating cylinder bleed port.

(2) Pressurize main hydraulic power system.

(a) Disconnect pushrod from flap control valve operating crank.

(b) Move control valve crank to flaps retract position.

(c) Open applicable lockout cylinder bleed valve, close valve when length of extended portion of lockout cylinder piston rod is as follows:

1 Outboard 5.041 + .250 - 0

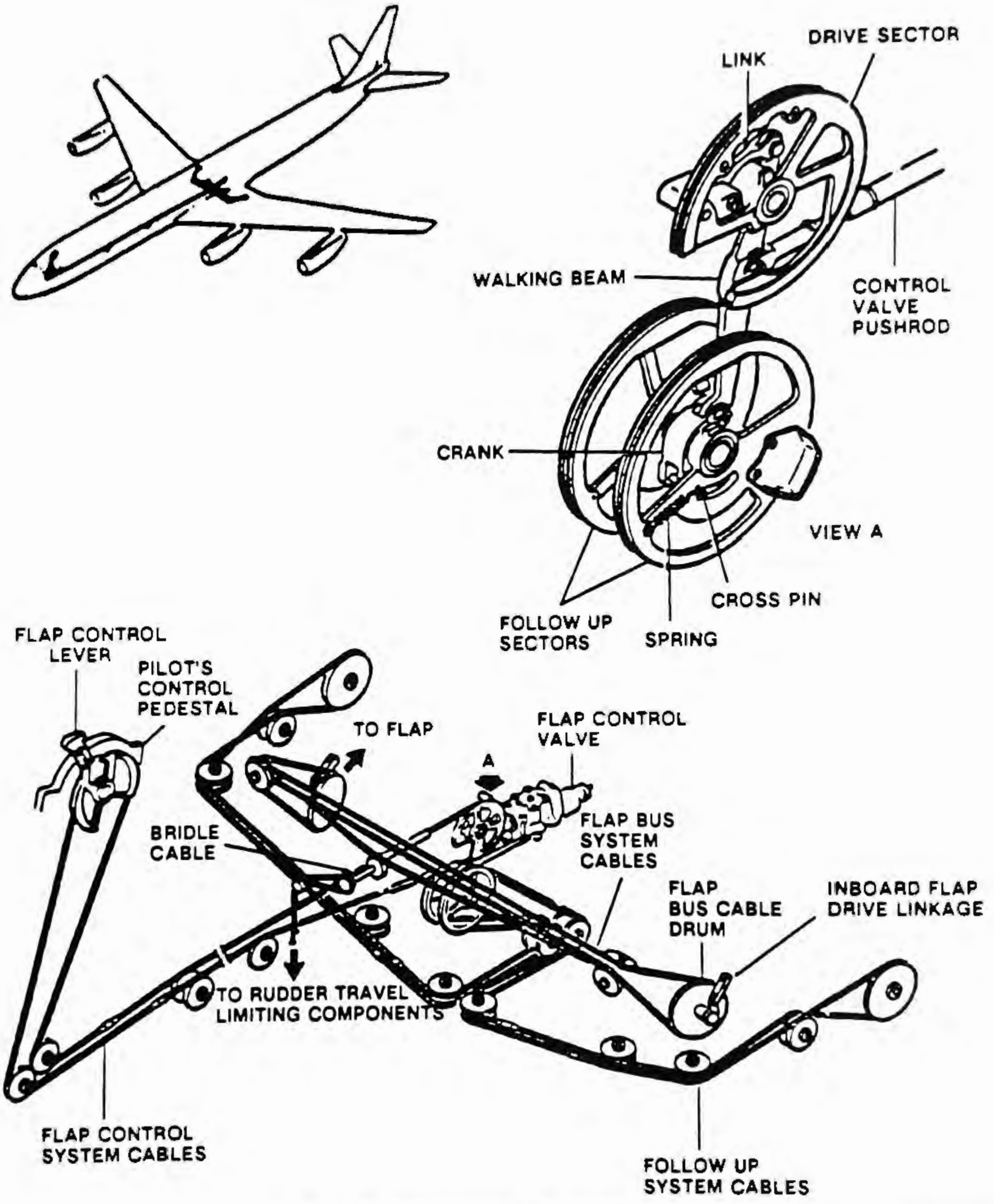
2 Midwing 6.731 + .250 - 0

3 Inboard 10.161 + .250 - 0

(d) Move control valve crank to extend flaps full down position.

(e) Reduce hydraulic pressure to zero.

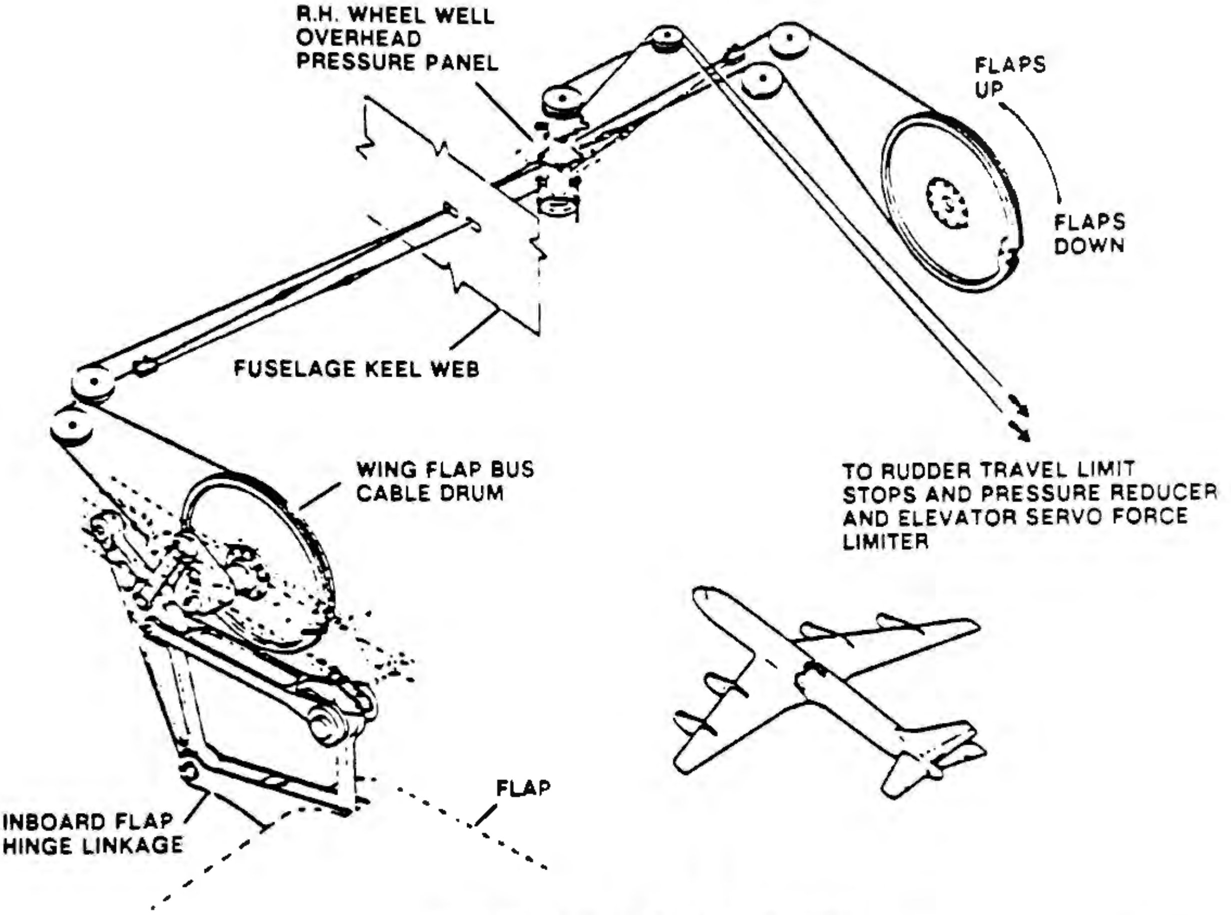
(f) Move control valve crank to retract flaps position to full up.



FLAP CONTROL SYSTEM

FTX80269

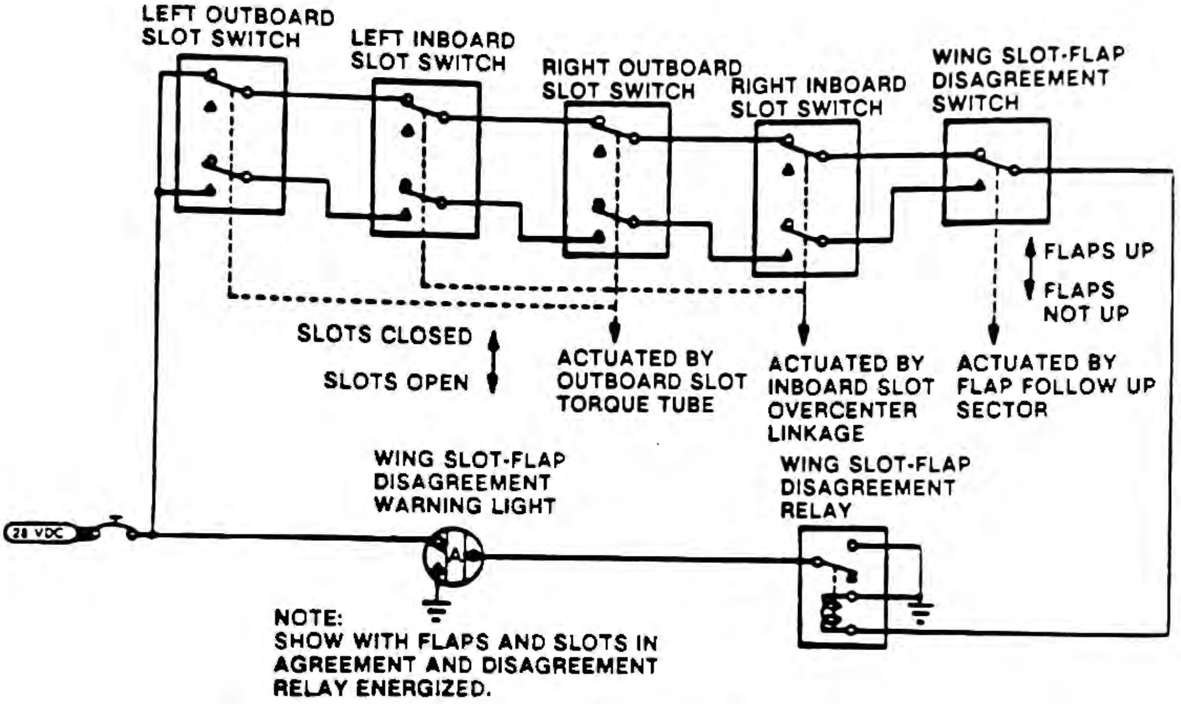
Figure 27-59


R.H. WHEEL WELL OVERHEAD PRESSURE PANEL
FLAPS UP
FLAPS DOWN
FUSELAGE KEEL WEB
WING FLAP BUS CABLE DRUM
TO RUDDER TRAVEL LIMIT STOPS AND PRESSURE REDUCER AND ELEVATOR SERVO FORCE LIMITER
FLAP
INBOARD FLAP HINGE LINKAGE

FLAP BUS-CABLE SYSTEM

FTX80270

Figure 27-60


LEFT OUTBOARD SLOT SWITCH
LEFT INBOARD SLOT SWITCH
RIGHT OUTBOARD SLOT SWITCH
RIGHT INBOARD SLOT SWITCH
WING SLOT-FLAP DISAGREEMENT SWITCH
FLAPS UP
FLAPS NOT UP
SLOTS CLOSED
SLOTS OPEN
ACTUATED BY OUTBOARD SLOT TORQUE TUBE
ACTUATED BY INBOARD SLOT OVERCENTER LINKAGE
ACTUATED BY FLAP FOLLOW UP SECTOR
WING SLOT-FLAP DISAGREEMENT WARNING LIGHT
WING SLOT-FLAP DISAGREEMENT RELAY
28 VDC
A
NOTE:
SHOW WITH FLAPS AND SLOTS IN AGREEMENT AND DISAGREEMENT RELAY ENERGIZED.

WING SLOT -- FLAP DISAGREEMENT INDICATING SYSTEM -- SCHEMATIC

FTX80302

Figure 27-62

(b) As the flaps move, the center drive linkage on each flap drives the follow-up system cables, causing the follow-up sectors to rotate. The crosspin through the sectors drives a crank, which in turn moves the walking beam in a direction opposite to the movement caused by the drive sector. This reverse movement of the walking beam causes the pushrod to move the control valve slide toward the neutral position. When the flaps reach the position selected by the control lever, the initial displacement of the walking beam caused by the drive sector is equaled by the reverse displacement caused by the follow-up sectors and the control valve slide reaches the neutral position, thus halting further movement of the flaps. Since the crosspin is installed through slots in the follow-up sectors, the sectors are allowed to rotate independently. The crosspin is held against the forward edge of each sector slot by a spring. During extension of the flaps, the sector rotated by the leading flap drives the crosspin while the spring attached to the lagging sector is extended allowing the crosspin to move in the slot. This arrangement prevents flap extension in excess of control lever setting in the event that the flaps do not extend symmetrically. During retraction of the flaps, the crosspin is driven by the sector rotated by the trailing flap. As the sector rotates, the crosspin is held against the forward edge of the slots by the springs, causing the crank to move. If the flaps do not retract symmetrically, the spring connecting the crosspin to the leading flap follow-up sector extends and the crosspin does not move until the sector driven by the trailing flap rotates.

(c) As the flaps are extended or retracted, mechanical linkage attached to the inboard hinge drives the flap bus system cable drums. Any tendency of one flap to travel out of synchronization with the other is checked by the bus cable system, which interconnects the two drums, thus maintaining symmetrical operation of the flaps. Operation of the rudder is affected by operation of the flaps. When the flaps are extended 10 degrees or more, the bridle cable system connected to the flap bus cable system operates the rudder travel limit stop hook and the rudder hydraulic pressure reducer valve so that rudder travel is unrestricted as low airspeeds.

(2) Hydraulic Components (See Figure 27-61)

(a) When the flap control valve slide is moved to the extend position, 3000 psi hydraulic pressure from the main hydraulic system is directed through passages in the valve to the internal restrictor valve. The restrictor valve allows restricted fluid flow through the control valve extend port to the three lockout cylinder inlet ports. Fluid stored in the outlet side of each lockout cylinder piston is forced under pressure through the outlet ports. Pressure from the outboard lockout cylinder is ported directly to the extend side of each outboard actuating cylinder. Pressure from the midwing and inboard lockout cylinders is directed through a balanced relief valve to the extend sides of the corresponding actuating cylinders. Fluid displaced from the retract side of the outboard actuating cylinders is returned to the engine-driven hydraulic pump suction lines. Fluid returning from the retract side of each midwing and inboard actuating cylinder is directed through control valve retract port to the main hydraulic system return line.

(b) When the flaps are in the position corresponding to the control lever setting, the control valve slide is returned to the neutral position, and hydraulic fluid is locked in both sides of the system, maintaining the flaps in the selected position. A check valve in the retract passage of the control valve holds fluid in the retract side of the system to prevent flap droop.

(c) When the control valve slide is moved to the retract position, hydraulic pressure from the main hydraulic system is directed through the internal anti-droop check valve and a two-way restrictor valve to the retract sides of the midwing and inboard actuating cylinders. Fluid displaced from the extend sides of these cylinders is returned through the balanced relief valves to the midwing and inboard lockout cylinders. The action of the midwing and inboard actuating cylinders, assisted by airloads against the flaps, is sufficient to retract the flaps fully during flight. No hydraulic pressure is applied to the outboard actuating cylinders during retraction of the flaps; but, at the flaps retract, fluid is drawn into the retract side of the cylinders from the engine-driven hydraulic pump suction lines. Fluid from the extend side of each outboard actuating cylinder is returned directly to the outboard lockout cylinder. Fluid displaced by each lockout cylinder piston is returned through the control valve to the main hydraulic system return line.

(d) A blowback relief valve is incorporated into the flap control valve. When the flaps are extended, excessive airloads against the flaps could cause hydraulic pressure to build up in the extend side of the system. If this pressure reaches approximately 3100 psi, the blowback relief valve will open, directing excessive pressure to the control valve return port. This permits the flaps to partially retract, thus preventing structural damage. When the airload is relieved, the blowback valve is reseated and the flaps return to the selected position.

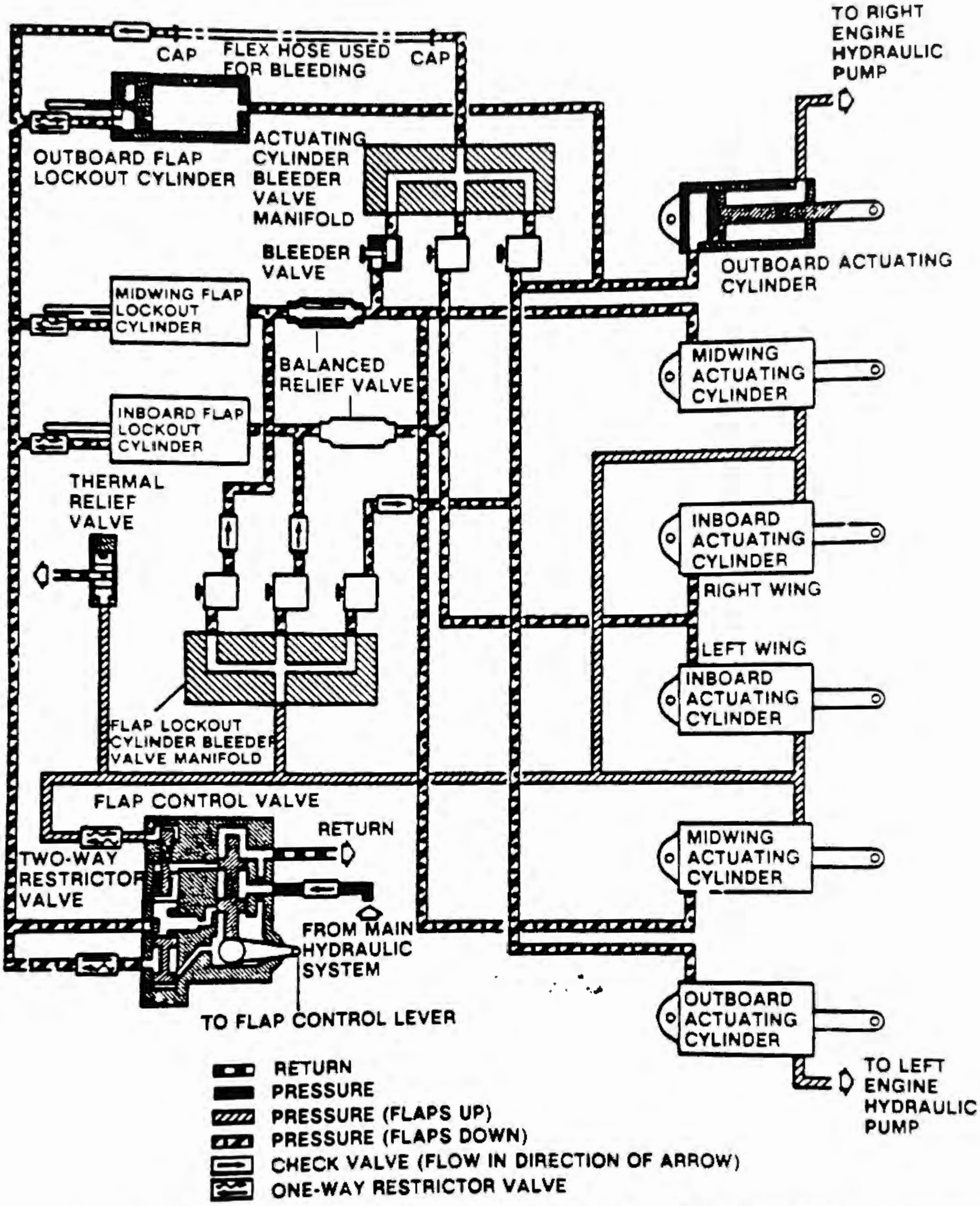
(c) If the flaps are extended 10 or more degrees and the engine throttles are retarded to less than 12 percent continuous thrust approximately 1/2 inch from idle stop) with the landing gear not down and latched, a 28-vdc circuit is completed through closed contacts of the stall warning mode transfer relay (energized closed by the flap landing gear warning switch, and the throttle limit switches to actuate the warning horn. The warning horn may be silenced by depressing the warning horn cutoff switch. The warning horn circuit uses the normally closed contacts of the horn cutoff relays. Depression of the cutoff switch energizes these relays and opens the contacts, thus interrupting the circuit and silencing the horn.

(d) If the flaps are extended 35 or more degrees with the landing gear not down and latched, a 28-vdc circuit is completed through closed contacts of the stall warning mode transfer relay (energized closed by the flap landing gear warning switch) and the secondary warning switch to actuate the warning horn. This circuit does not include the horn cutoff relays, so the warning horn cannot be silenced unless the flaps are retracted to a position less than 35 degrees of extension or the landing gear is moved to the down and latched position.

(4) Flap Takeoff Warning System (See Figure 27-64)

(a) The flap takeoff warning system is a mechanically actuated electrical system that will provide an intermittent audible warning if the throttles are advanced for takeoff with the flaps not within the takeoff range. The system consists of a flap takeoff warning switch that is electrically connected to components of the takeoff and cabin pressure warning system. The flap takeoff warning switch, located in the right main wheel well, is actuated by a cam attached to the right flap follow-up sector.

(b) When the flaps are positioned from zero to 6 (±3) degrees or below 30 (±3) degrees the flap takeoff warning switch contacts are closed by the cam on the flap follow-up sector. If the airplane is on the ground and the No. 1 and 3 engine throttles are advanced for takeoff with the warning switch in this position, a 28-vdc circuit is completed to actuate the warning horn. The horn cannot be silenced unless the throttles are retarded or the flaps


TO RIGHT ENGINE HYDRAULIC PUMP
CAP
FLEX HOSE USED FOR BLEEDING
CAP
OUTBOARD FLAP LOCKOUT CYLINDER
ACTUATING CYLINDER BLEEDER VALVE MANIFOLD
BLEEDER VALVE
OUTBOARD ACTUATING CYLINDER
MIDWING FLAP LOCKOUT CYLINDER
BALANCED RELIEF VALVE
MIDWING ACTUATING CYLINDER
INBOARD FLAP LOCKOUT CYLINDER
THERMAL RELIEF VALVE
INBOARD ACTUATING CYLINDER
RIGHT WING
LEFT WING
INBOARD ACTUATING CYLINDER
FLAP LOCKOUT CYLINDER BLEEDER VALVE MANIFOLD
FLAP CONTROL VALVE
RETURN
TWO-WAY RESTRICTOR VALVE
MIDWING ACTUATING CYLINDER
FROM MAIN HYDRAULIC SYSTEM
OUTBOARD ACTUATING CYLINDER
TO FLAP CONTROL LEVER
TO LEFT ENGINE HYDRAULIC PUMP
RETURN
PRESSURE
PRESSURE (FLAPS UP)
PRESSURE (FLAPS DOWN)
CHECK VALVE (FLOW IN DIRECTION OF ARROW)
ONE-WAY RESTRICTOR VALVE

FLAP CONTROL SYSTEM -- HYDRAULIC SCHEMATIC FTX80274

Figure 27-61

18. Flap Lockout Servicing

A. Fill Lockout Cylinder

(1) Pressurize hydraulic power system

(a) Move flap control lever to up position

(b) Open applicable lockout cylinder bleed valve

1 Close bleed valve when extended portion of lockout cylinder piston rod is as follows:

a Outboard 5.041 + .250 - 0

b Midwing 6.731 + .250 - 0

c Inboard 10.161 + .250 - 0 Open only one bleed valve at a time. If more than one is opened, the flaps will extend and become hydraulically locked.

(c) Safety bleed valve

(d) Shut off main hydraulic system

B. Check Lockout Cylinder For Air

(1) Disconnect pushrod from flap control valve operating crank.

(2) Pressurize main hydraulic power system.

(a) Move flap operating crank to extend flaps, and hold in extend position.

(b) Measure and record lockout cylinder piston rod extended from cylinder.

(c) Reduce hydraulic pressure to zero.

(d) Move operating crank to retract position and then to extend position. Hold in extend position.

B. Operation

(1) When the airplane electrical buses are energized and the flap position indicator circuit breakers are closed, the flap position indicating system is continuously operating, indicating the position of each flap. As each flap is moved, mechanical linkage rotates the corresponding flap transmitter shaft. Rotation of the shaft creates a varying voltage, which is then transmitted to the corresponding selsyn element in the flap position indicator. This voltage causes the indicator element to set up a magnetic field, which aligns the indicator rotor shaft and pointer to show the flap position. The transmitters have an internal ratio of 2 to 1; that is, every degree of transmitter shaft rotation produces a voltage that results in 2 degrees of indicator pointer movement.

(2) Since the two indicator pointers are mounted one behind the other, any mismatch in flap positions is shown directly on the indicator. A mismatch of 3 degrees between left and right flap positions is allowable. This 3-degree mismatch is indicated when the extreme tip of the left flap is aligned with the edge of the mask on the right flap pointer. If the tip of the pointer extends beyond the mask, a mismatch greater than 3 degrees will be indicated.

21. Spoiler and Drag - Description and Operation

A. General (See Figure 27-66)

(1) There are five spoiler panels on the trailing edge of each wing, forward of the flaps. The three outboard panels on each wing are lateral control spoilers and have two functions. During low speed flight when the landing gear is extended, the lateral control spoilers aid the ailerons in lateral control of the airplane, and are controlled by the aileron control wheels. During the landing roll, the lateral control spoilers are used along with the two inboard spoiler panels as ground spoilers. The ground spoilers supplement the flaps, to increase drag and reduce speed of the airplane during the landing roll, by spoiling the lift of the wing. During use as ground spoilers, the spoiler panels are controlled manually by the spoiler control lever, or the control lever may be set so that the spoiler panels are operated automatically when the main landing wheels spin on contact with the ground. The spoiler system consists of a spoiler hydraulic power system, spoiler control and actuating systems, and a spoiler takeoff warning system.

1 Crank will move to this position by internal spring.

(g) Open applicable lockout cylinder bleed valve.

(3) Pressurize main hydraulic system

(a) When lockout cylinder piston rod is fully extended, simultaneously close lockout cylinder bleed valve and open corresponding actuating cylinder bleed valve.

(b) When flaps retract completely, close actuating cylinder bleed valve.

(c) Repeat bleeding procedure for remaining lockout cylinders.

(d) Check lockout cylinder for air.

(e) Remove flexible hose.

(f) Connect pushrod to control valve operating crank.

(g) Safety all bleed valves with lockwire.

(h) Remove pressure source to hydraulic system.

19. Flap Warning System - Description and Operation

A. General

(1) The flap warning system consists of three subsystems: the wing slot -- flap disagreement indicating system, the flap landing gear warning system, and the flap takeoff warning system.

(2) Wing Slot -- Flap Disagreement Indicating System (See Figure 27-62)

(a) The wing slot - flap disagreement indicating system is a mechanically actuated electrical system that provides visual indication if the flaps and slots are not in agreement. If the flaps are extended and one or more slots remain closed, or if the flaps are fully retracted and one or more slots are not fully closed, an amber light in the flight compartment will come on.

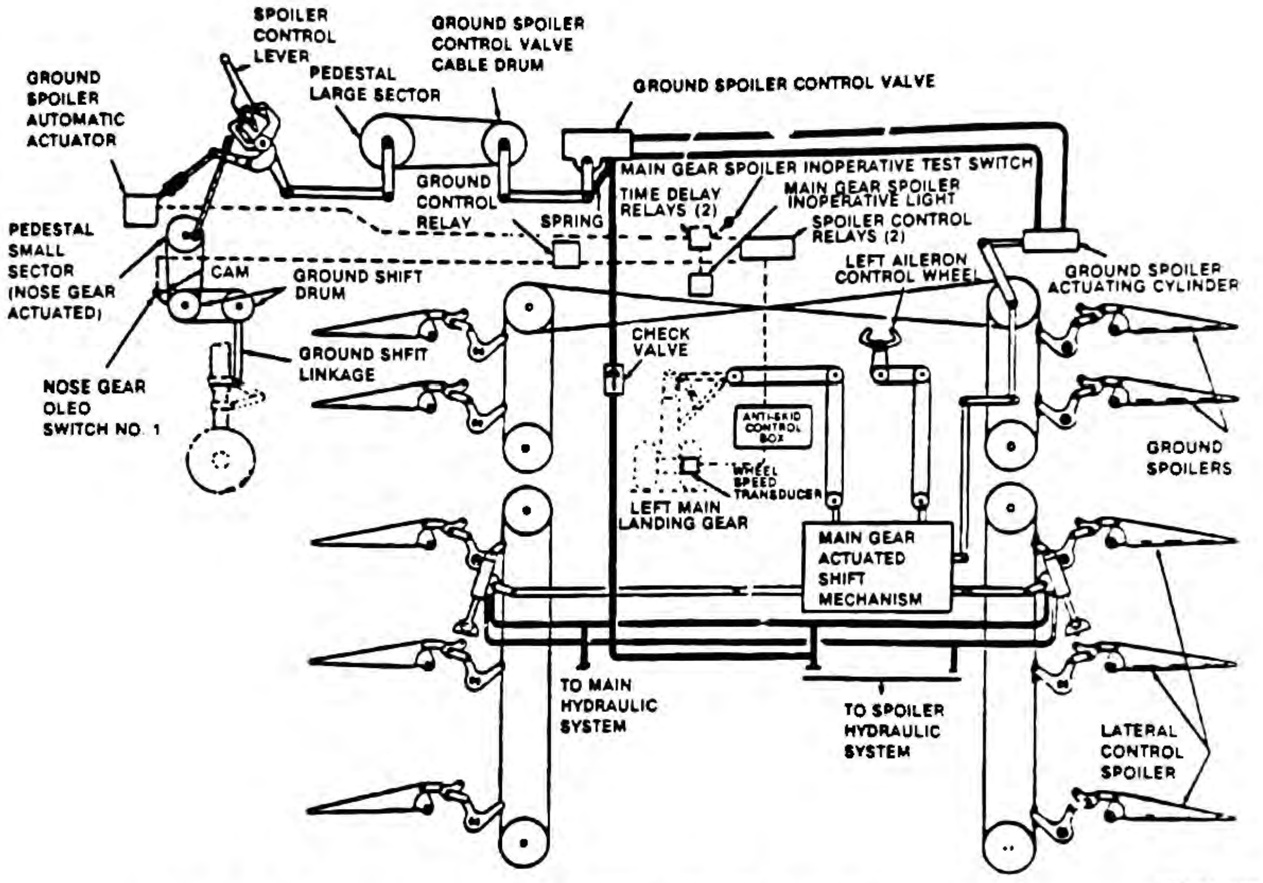
(b) The system consists of four slot disagreement switches, a slot-flap disagreement switch, a relay, and a press-to-test warning light. The inboard slot switches, one located adjacent to each inboard slot actuating cylinder, are actuated by movement of the inboard slot over-center linkage. The outboard slot switches, one located adjacent to each inboard slot actuating cylinder, are actuated by movement of the slot torque tube. The slot-flap switch, located in the right main wheel well, is actuated by a cam on the left flap follow-up sector.

(c) The warning light is connected electrically to the 28-vdc electrical power supply and through normally closed contacts of the relay to ground. In normal operation, when the flaps and slots are in agreement, a 28-vdc series circuit is completed through the five switches to energize the relay coil. When the relay is energized, the normally closed contacts are opened and the warning light goes off. If the position of one or more slots is not in agreement with the position of the flaps, the corresponding slot switch or switches interrupt the circuit to the relay coil. When the relay is deenergized, the contacts return to their normally closed position and the warning light comes on.

(3) Flap Landing Gear Warning System (See Figure 27-63)

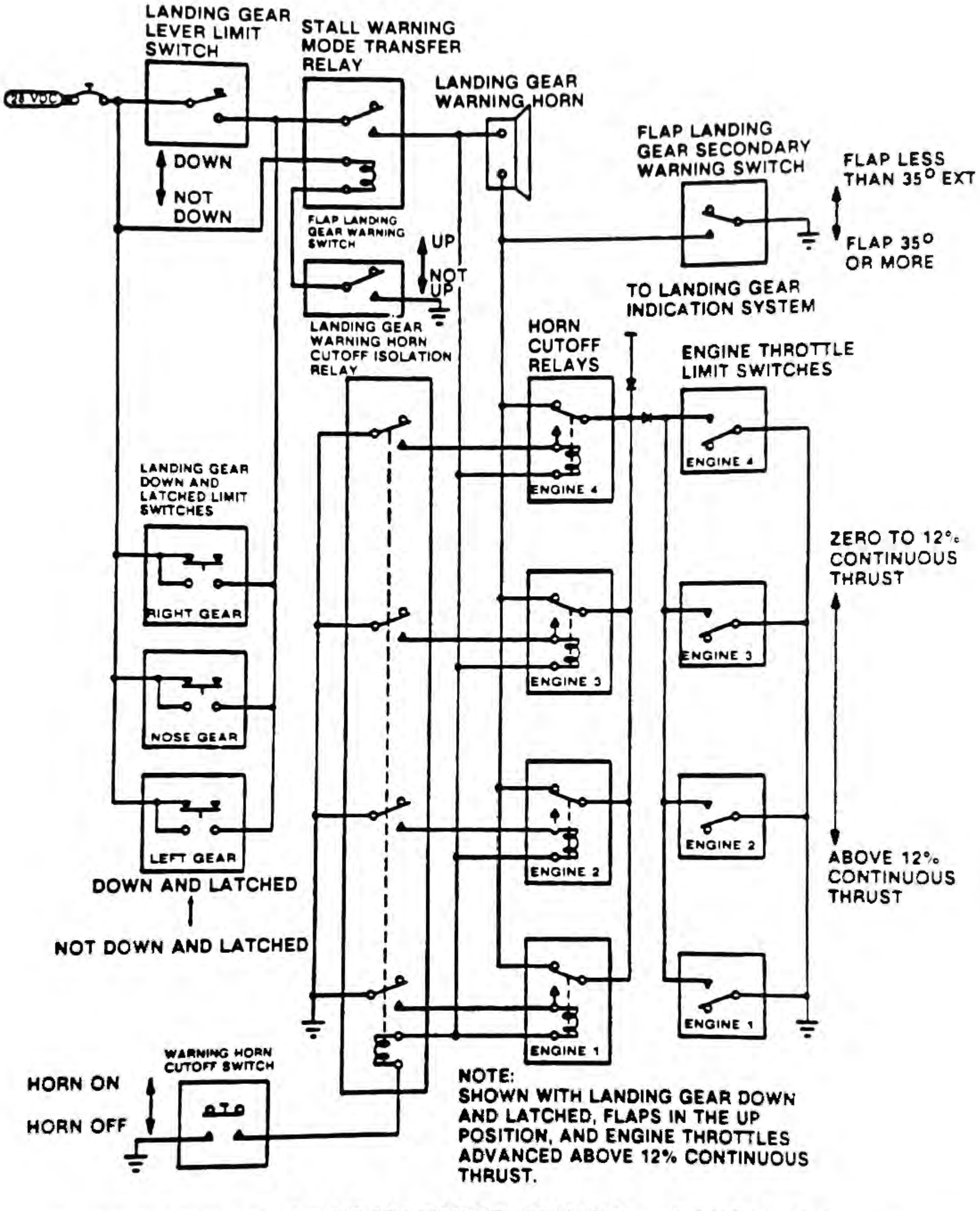
(a) The flap landing gear warning system is a mechanically actuated electrical system that will sound an audible warning if one or more engine throttles are retarded to less than 12 percent continuous thrust with the flaps extended 10 degrees or more and the landing gear not down and latched. A warning will also be sounded if the flaps are extended 35 degrees or more with the landing gear not down and latched.

(b) The system consists of a flap landing gear warning switch stall warning mode transfer relay, and a flap landing gear secondary warning switch. Both switches are electrically connected in the landing gear warning system. The flap landing gear warning switch, located in the right main wheel well, is actuated by a cam attached to the flap control system drive sector. The secondary warning switch, located in the pilot's control pedestal, is actuated by a cam attached to the flap control lever.


SPOILER CONTROL LEVER
GROUND SPOILER CONTROL VALVE CABLE DRUM
PEDESTAL LARGE SECTOR
GROUND SPOILER AUTOMATIC ACTUATOR
GROUND SPOILER CONTROL VALVE
MAIN GEAR SPOILER INOPERATIVE TEST SWITCH
GROUND CONTROL RELAY
SPRING
TIME DELAY RELAYS (2)
MAIN GEAR SPOILER INOPERATIVE LIGHT
SPOILER CONTROL RELAYS (2)
PEDESTAL SMALL SECTOR (NOSE GEAR ACTUATED)
CAM
GROUND SHIFT DRUM
LEFT AILERON CONTROL WHEEL
GROUND SPOILER ACTUATING CYLINDER
CHECK VALVE
GROUND SHFIT LINKAGE
NOSE GEAR OLEO SWITCH NO. 1
ANTI-SKID CONTROL BOX
WHEEL SPEED TRANSDUCER
GROUND SPOILERS
LEFT MAIN LANDING GEAR
MAIN GEAR ACTUATED SHIFT MECHANISM
TO MAIN HYDRAULIC SYSTEM
TO SPOILER HYDRAULIC SYSTEM
LATERAL CONTROL SPOILER
FTX80279

SPOILER CONTROL AND ACTUATING SYSTEM -- SCHEMATIC

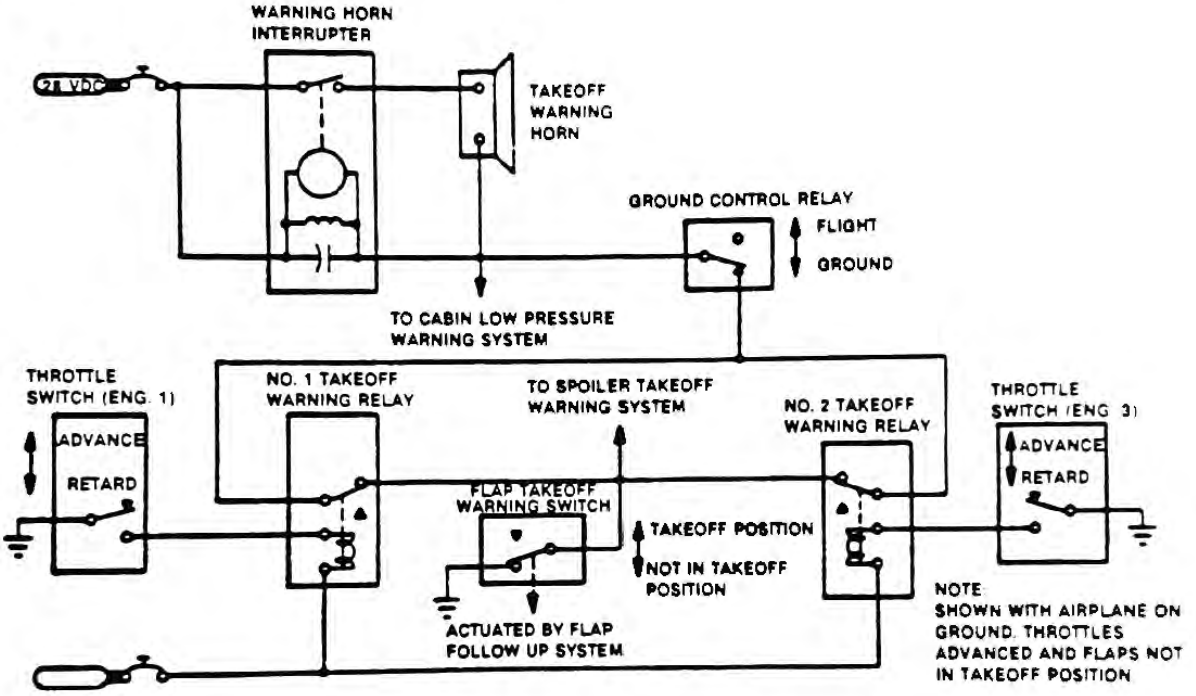
Figure 27-67


28 VDC
LANDING GEAR LEVER LIMIT SWITCH
DOWN
NOT DOWN
STALL WARNING MODE TRANSFER RELAY
FLAP LANDING GEAR WARNING SWITCH
UP
NOT UP
LANDING GEAR WARNING HORN CUTOFF ISOLATION RELAY
LANDING GEAR WARNING HORN
FLAP LANDING GEAR SECONDARY WARNING SWITCH
FLAP LESS THAN 35° EXT
FLAP 35° OR MORE
TO LANDING GEAR INDICATION SYSTEM
HORN CUTOFF RELAYS
ENGINE THROTTLE LIMIT SWITCHES
ENGINE 4
ENGINE 3
ENGINE 2
ENGINE 1
ZERO TO 12% CONTINUOUS THRUST
ABOVE 12% CONTINUOUS THRUST
LANDING GEAR DOWN AND LATCHED LIMIT SWITCHES
RIGHT GEAR
NOSE GEAR
LEFT GEAR
DOWN AND LATCHED
NOT DOWN AND LATCHED
WARNING HORN CUTOFF SWITCH
HORN ON
HORN OFF

NOTE:
SHOWN WITH LANDING GEAR DOWN AND LATCHED, FLAPS IN THE UP POSITION, AND ENGINE THROTTLES ADVANCED ABOVE 12% CONTINUOUS THRUST.

FLAP LANDING GEAR WARNING SYSTEM -- SCHEMATIC FTX80275

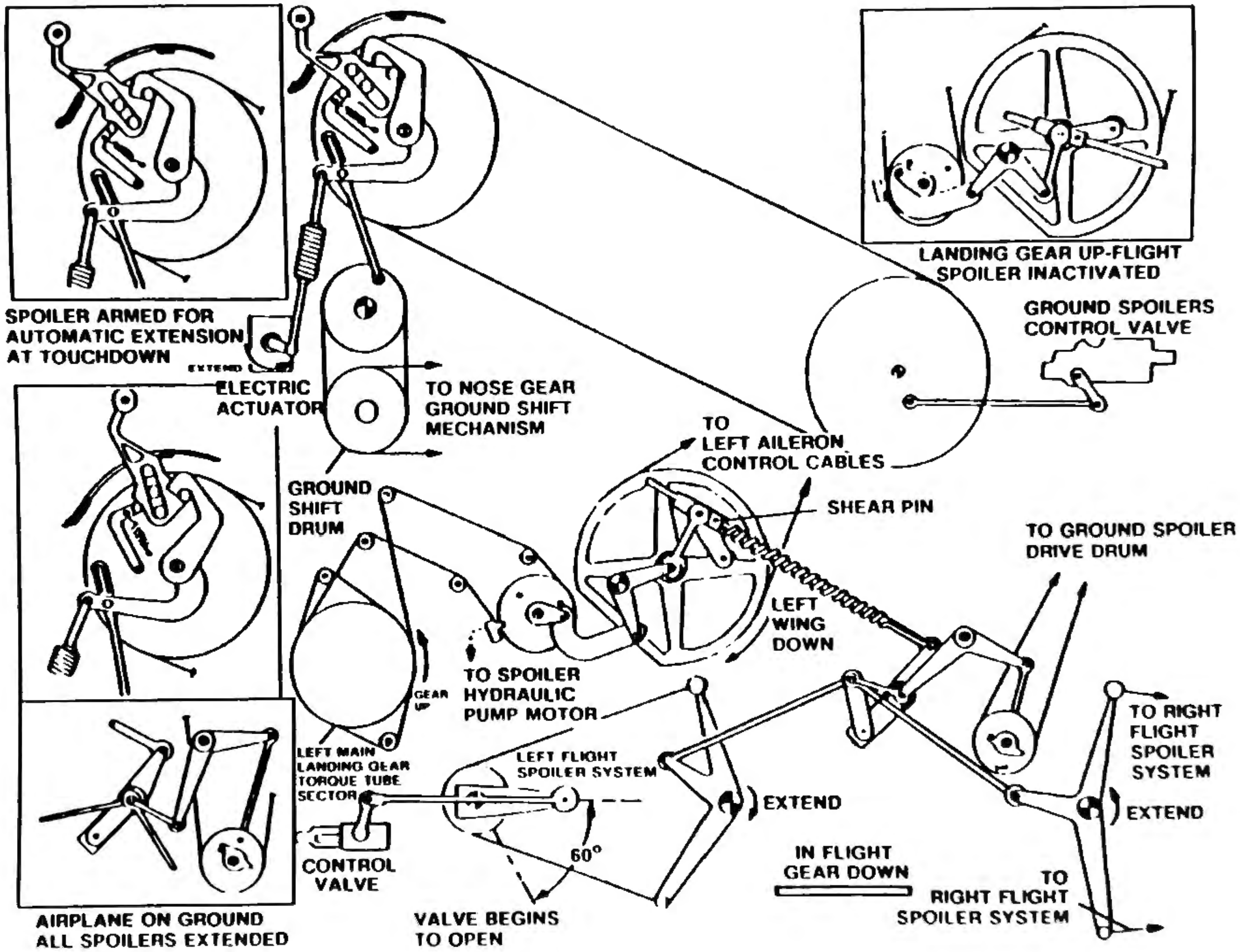
Figure 27-63



NOTE:
SHOWN WITH AIRPLANE ON GROUND. THROTTLES ADVANCED AND FLAPS NOT IN TAKEOFF POSITION

FLAP TAKEOFF WARNING SYSTEM -- SCHEMATIC FTX80303

Figure 27-64


SPOILER ARMED FOR AUTOMATIC EXTENSION AT TOUCHDOWN
EXTEND
ELECTRIC ACTUATOR
TO NOSE GEAR GROUND SHIFT MECHANISM
GROUND SHIFT DRUM
LANDING GEAR UP-FLIGHT SPOILER INACTIVATED
GROUND SPOILERS CONTROL VALVE
TO LEFT AILERON CONTROL CABLES
SHEAR PIN
TO GROUND SPOILER DRIVE DRUM
LEFT WING DOWN
TO SPOILER HYDRAULIC PUMP MOTOR
GEAR UP
LEFT MAIN LANDING GEAR TORQUE TUBE SECTOR
LEFT FLIGHT SPOILER SYSTEM
EXTEND
TO RIGHT FLIGHT SPOILER SYSTEM
EXTEND
IN FLIGHT GEAR DOWN
TO RIGHT FLIGHT SPOILER SYSTEM
60°
CONTROL VALVE
VALVE BEGINS TO OPEN
AIRPLANE ON GROUND ALL SPOILERS EXTENDED

SPOILER MECHANICAL CONTROL SYSTEM

FTX80282

Figure 27-68

are moved to within the takeoff range. To differentiate the horn from other audible warning system, an interrupter timer is included in the takeoff warning circuit so that the horn is sounded intermittently.

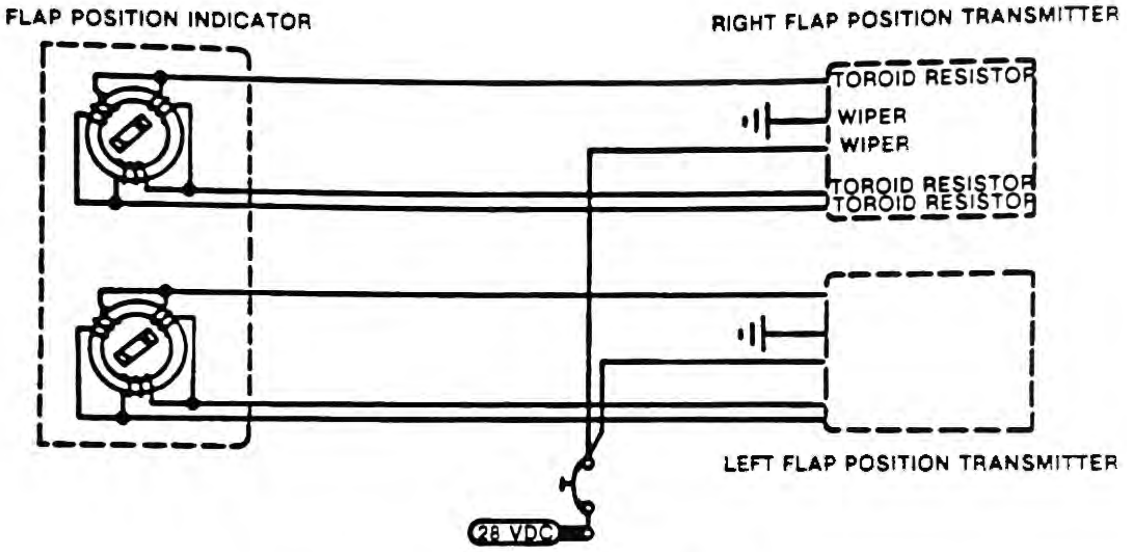
20. Flap Position Indicating System - Description and Operation

A. General (See Figure 27-65)

(1) The flap position indicating system is a mechanically actuated electrical system that transmits the positions of the left and right flaps to an indicator in the flight compartment. The system consists of two flap position transmitters, a flap position indicator, and mechanical linkage.

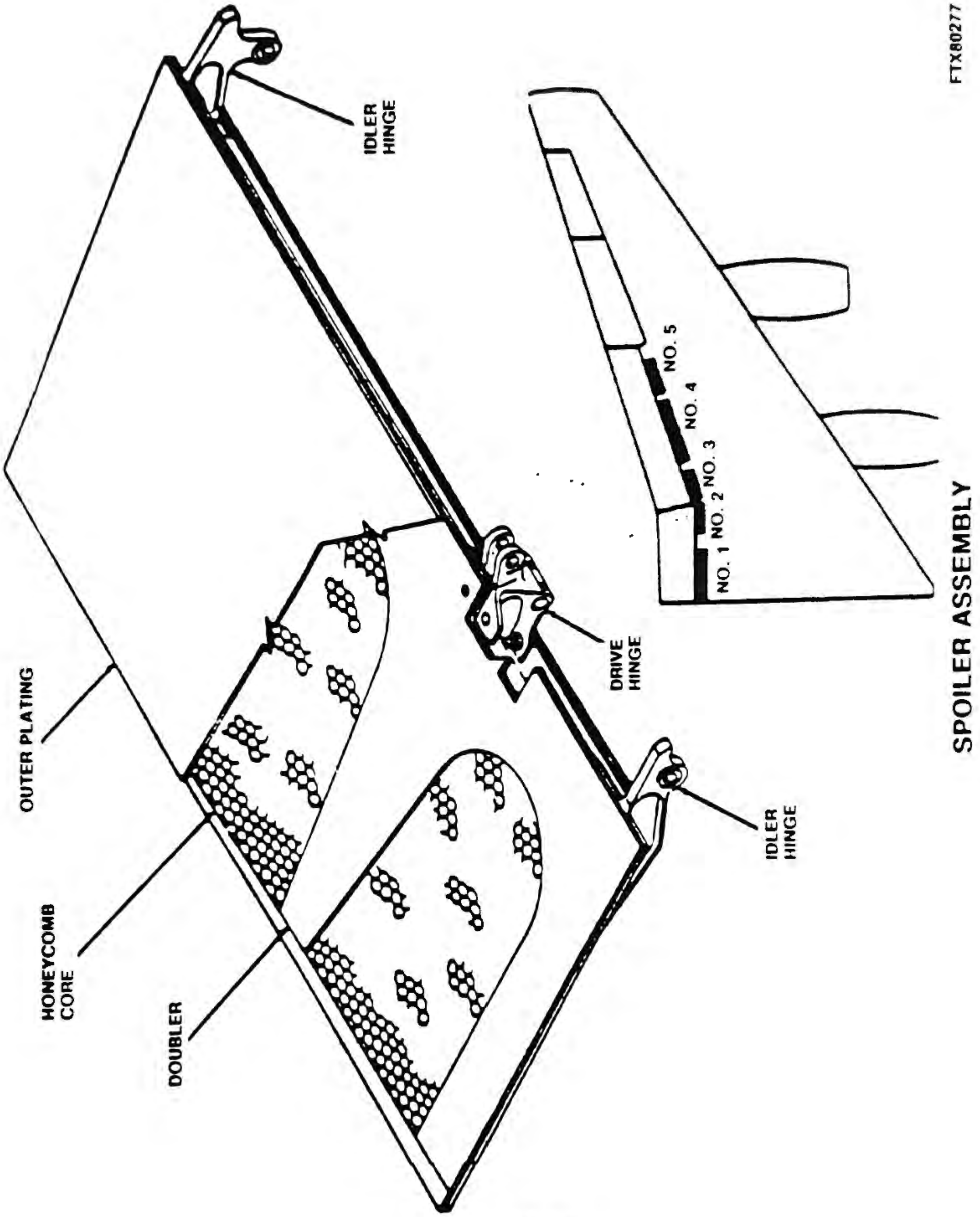
(2) The flap position transmitters are hermetically sealed, helium-filled, dc selsyn-type transmitters that convert mechanical rotation of an input shaft to an output voltage, which is then transmitter to the flap position indicator. The transmitters are located on the wing rear spar structure, one adjacent to each flap inboard drive hinge. an arm on the output shaft of each transmitter is connected by mechanical linkage to the flap drive linkage.

(3) The flap position indicator is a hermetically sealed, helium-filled, dual dc selsyn-type indicator that converts the input voltages received from both transmitters to mechanical movement of the indicator pointers. The two concentric pointers indicate the left and right flap positions on a single graduated scale. The indicator range is from zero degrees (flaps up) to 50 degrees (flaps down). A plastic outer pointer shows the position of the left flap. The pointer is fan-shaped with a mask covering 6 degrees of the indicator scale. A narrow metal pointer, mounted behind the plastic pointer, indicates the position of the right flap.



FLAP POSITION INDICATING SYSTEM -- SCHEMATIC FTX80276

Figure 27-65



SPOILER ASSEMBLY

Figure 27-66

(2) The spoiler hydraulic power system is an independent 3000 psi hydraulic system which supplies hydraulic pressure to operate the lateral control and ground spoiler panels. The main hydraulic power system, connected through a solenoid-operated selector valve to the spoiler system, provides a standby method of pressurizing the spoiler hydraulic power system.

(3) The spoiler control and actuating systems consist of a mechanical control system, an automatic control system, and mechanical actuating system. The mechanical control system provides a means of manually operating the spoiler hydraulic power system control valves with the spoiler control lever or with the aileron control wheels. A main gear actuated shift mechanism shifts control of the lateral control spoilers from the aileron system to the spoiler control lever when the lateral control spoilers are used as ground spoilers. The automatic control system automatically operates the ground spoiler control valve to extend the spoiler panels when the main landing gear wheels spin on contact with the ground. The mechanical actuating system consists of the cable systems and mechanical linkages that are driven by the spoiler hydraulic power system components to extend and retract the spoiler panels.

(4) The spoiler takeoff warning system is a mechanically actuated, electrical system that provides an audible warning if the engine throttles are advanced for takeoff with the spoiler panels not in the retracted position. The system also causes an indicator light in the flight compartment to come on when the spoilers are not retracted.

22. Spoiler Control and Actuating System - Description and Operation

A. General (See Figure 27-67)

(1) The spoiler control and actuating system consists of a mechanical control system, an automatic control system, and a mechanical actuating system.

(2) Spoiler Mechanical Control System (See Figures 27-68, 27-69 & 27-70)

(a) The spoiler mechanical control system provides a means of controlling the spoiler hydraulic system control valves with the aileron control wheels or the spoiler control lever. The system consists of the spoiler control lever, a main gear actuated shift mechanism, and interconnecting cable system.

(b) The spoiler control lever, located on the pilot's control pedestal, is connected by mechanical linkage to two sectors on the main shaft of the pedestal. The largest of the two sectors is connected by cable system to the ground spoiler control valve cable drum in the right wheel well. Mechanical linkage connects the cable drum to the ground spoiler control valve operating lever.

(c) The main gear actuated shift mechanism, located in the left wheel well, shifts control of the lateral control spoilers from the aileron control wheels to the spoiler control lever so that the lateral control spoilers can be used in conjunction with the ground spoilers. The mechanism consists of upper and lower cable drums, sector, and two bellcranks, all mounted on a common support and interconnected by mechanical linkage. The upper cable drum is connected by cable to a cable drum on the main gear torque tube. Cables connect the lower cable drum to the ground spoiler actuating system cable drum in the left wheel well. The sector is connected by cables to the left aileron control cable system. The sector is also connected by pushrod to a control linkage mounted on the support. The control linkage is connected by pushrods to the two bellcranks which are mounted on the lower corners of the support. Cables connect each bellcrank to the corresponding lateral control spoiler hydraulic control valve linkage.

GROUND SPOILER OPERATION

Takeoff and during flight:

When the ground spoiler control lever is in RETRACT position, the two ground spoilers on each wing are inoperative and the lateral control spoilers will work only in conjunction with the ailerons, provided the main gear is extended. When the ground shift is in flight mode (nose gear strut extended) the ground spoilers are locked in retracted position by a mechanical latch. This prevents movement of the ground spoiler control lever. Thus the ground spoilers cannot be operated.

Should the nose gear strut, however, not extend or if a malfunction of the ground shift system occurs after takeoff, the ground spoiler mechanical latch will not lock and the ground spoilers can be extended by moving the ground spoiler control lever to EXTEND position. If, after takeoff, the ground spoiler electric actuator should remain in ground position, the mechanical latch will lock the ground spoiler mechanism as soon as the ground shift goes into flight mode, thus preventing operation of the ground spoilers during flight.

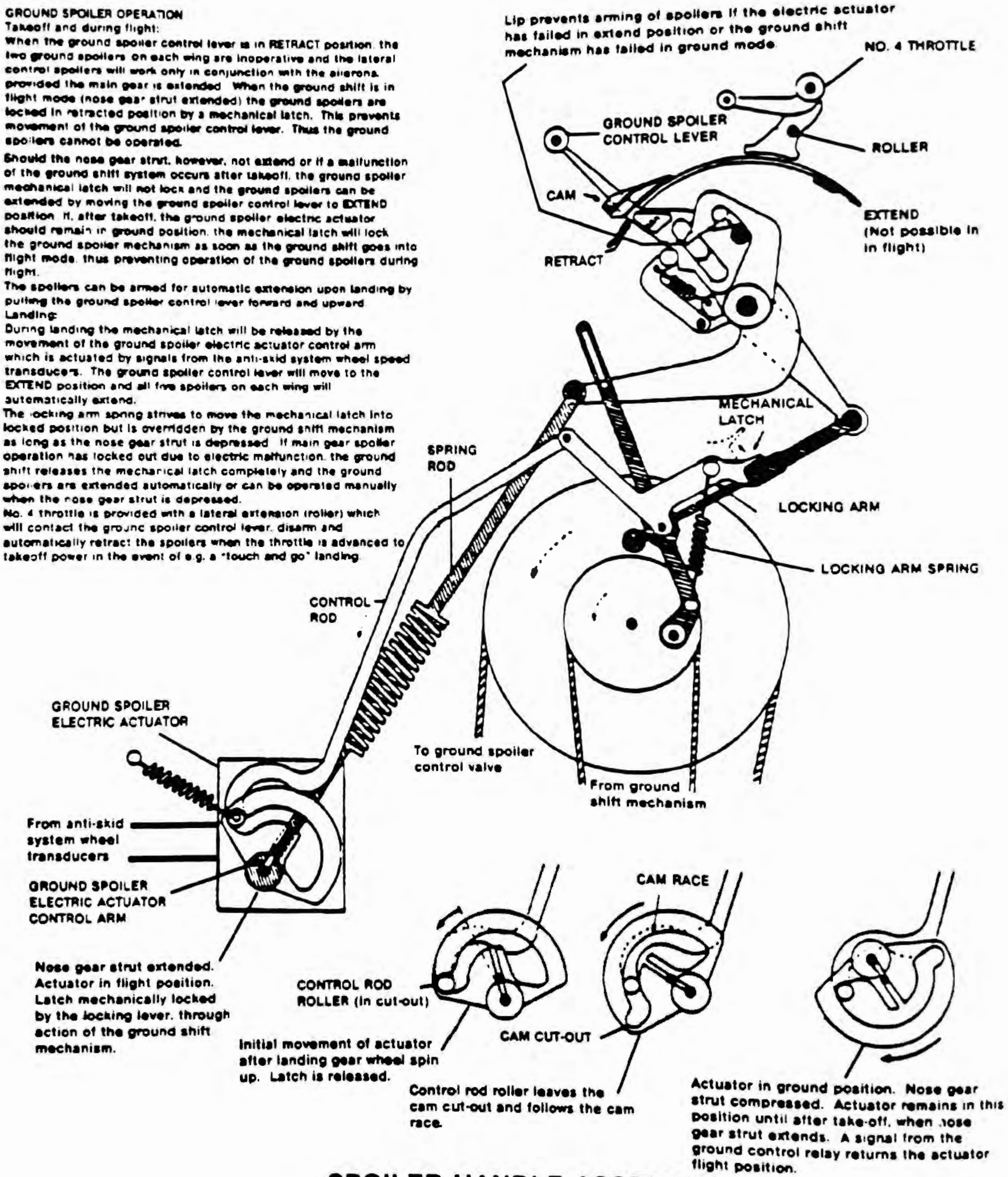
The spoilers can be armed for automatic extension upon landing by pulling the ground spoiler control lever forward and upward.

Landing:

During landing the mechanical latch will be released by the movement of the ground spoiler electric actuator control arm which is actuated by signals from the anti-skid system wheel speed transducers. The ground spoiler control lever will move to the EXTEND position and all five spoilers on each wing will automatically extend.

The locking arm spring strives to move the mechanical latch into locked position but is overridden by the ground shift mechanism as long as the nose gear strut is depressed. If main gear spoiler operation has locked out due to electric malfunction, the ground shift releases the mechanical latch completely and the ground spoilers are extended automatically or can be operated manually when the nose gear strut is depressed.

No. 4 throttle is provided with a lateral extension (roller) which will contact the ground spoiler control lever, disarm and automatically retract the spoilers when the throttle is advanced to takeoff power in the event of e.g. a "touch and go" landing.


NO. 4 THROTTLE
GROUND SPOILER CONTROL LEVER
ROLLER
CAM
EXTEND (Not possible in in flight)
RETRACT
MECHANICAL LATCH
SPRING ROD
LOCKING ARM
LOCKING ARM SPRING
CONTROL ROD
GROUND SPOILER ELECTRIC ACTUATOR
From anti-skid system wheel transducers
GROUND SPOILER ELECTRIC ACTUATOR CONTROL ARM
To ground spoiler control valve
From ground shift mechanism
CAM RACE
CONTROL ROD ROLLER (in cut-out)
CAM CUT-OUT
FTX80278

Lip prevents arming of spoilers if the electric actuator has failed in extend position or the ground shift mechanism has failed in ground mode.

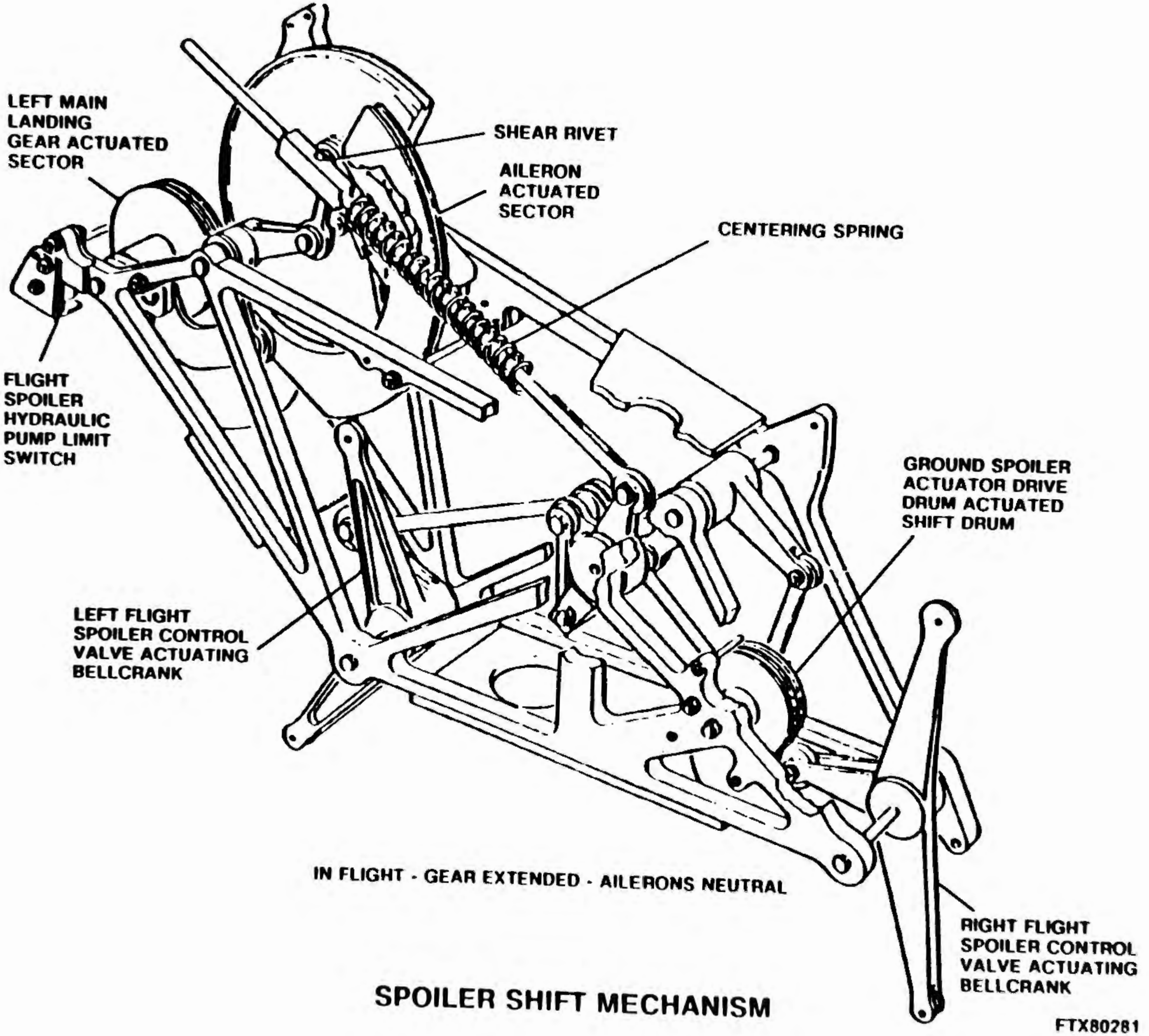
Nose gear strut extended. Actuator in flight position. Latch mechanically locked by the locking lever, through action of the ground shift mechanism.

Initial movement of actuator after landing gear wheel spin up. Latch is released.

Control rod roller leaves the cam cut-out and follows the cam race.

Actuator in ground position. Nose gear strut compressed. Actuator remains in this position until after take-off, when nose gear strut extends. A signal from the ground control relay returns the actuator flight position.

SPOILER HANDLE ASSEMBLY
Figure 27-69


LEFT MAIN LANDING GEAR ACTUATED SECTOR
SHEAR RIVET
AILERON ACTUATED SECTOR
CENTERING SPRING
FLIGHT SPOILER HYDRAULIC PUMP LIMIT SWITCH
GROUND SPOILER ACTUATOR DRIVE DRUM ACTUATED SHIFT DRUM
LEFT FLIGHT SPOILER CONTROL VALVE ACTUATING BELLCRANK
RIGHT FLIGHT SPOILER CONTROL VALVE ACTUATING BELLCRANK

IN FLIGHT - GEAR EXTENDED - AILERONS NEUTRAL

SPOILER SHIFT MECHANISM

FTX80281

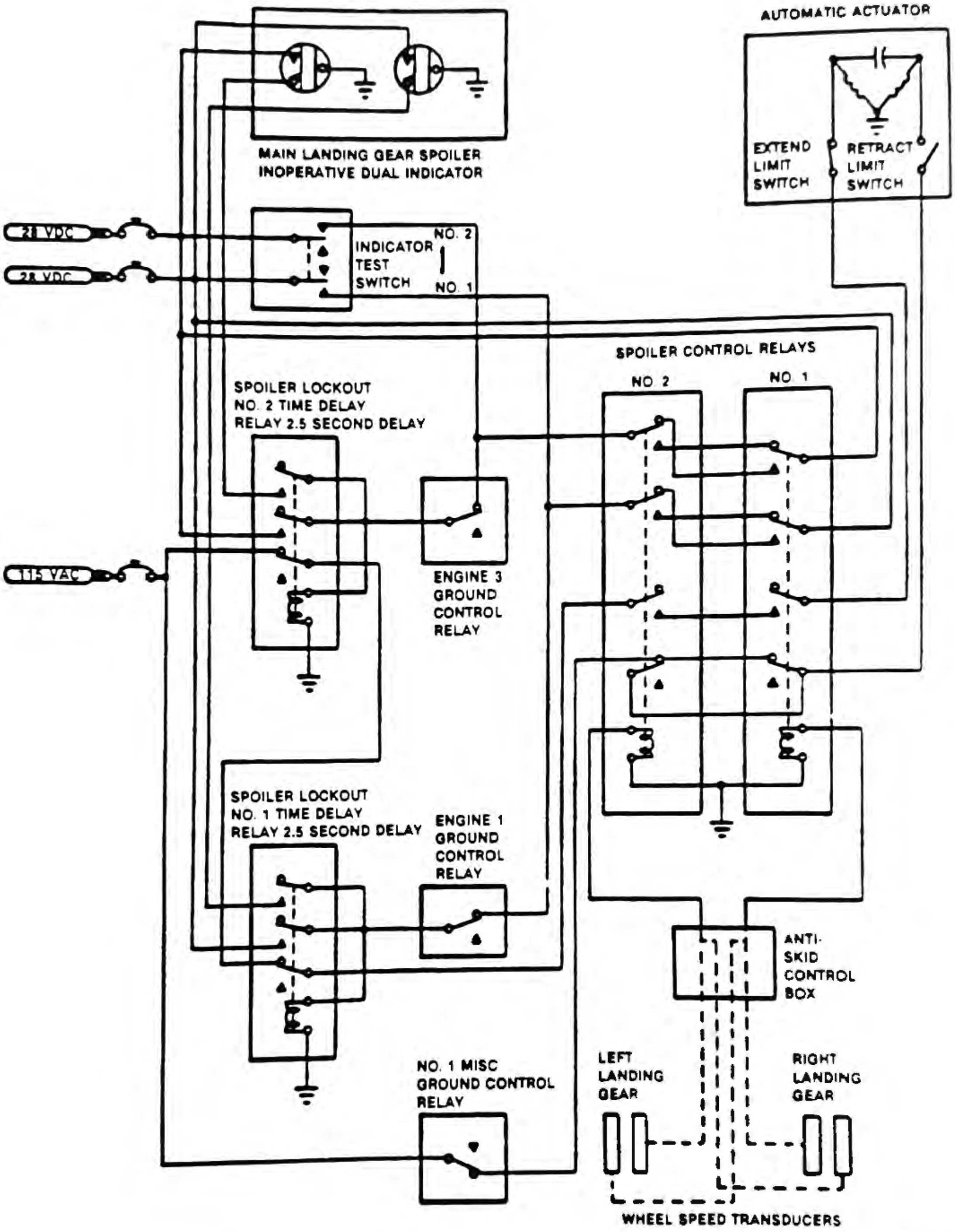
Figure 27-70

(3) Spoiler Automatic Control System (See Figure 27-71)

(a) The spoiler automatic control system automatically extends the spoiler panels during the landing roll. The system consists of an automatic actuator, ground shift mechanism, two spoiler control relays, two time delay relays, parts of the anti-skid control box, and a spoiler inoperative indicator.

(b) The automatic actuator, located in the forward lower section of the control pedestal, automatically actuates the spoiler control lever to extend the ground spoilers on receipt of signals from the anti-skid control box, or on compression of the nose gear oleo strut. The actuator consists of an ac reversible motor, gears, and extend limit switch, retract limit switch, and a housing. The motor is connected electrically to the 115-vac power supply through the contacts of the limit switches, spoiler control relays, time delay relays, and ground control relay. The motor rotor is connected through the gears to an output shaft. A crank on the output shaft is connected by pushrod to a crank on the base of the spoiler control lever. The spoiler control lever crank is also connected by pushrod to a small sector on the main sector shaft of the control pedestal. The sector is connected by cables to the ground shift mechanism cable drum. Mechanical linkage connects the cable drum to the nose gear upper torque link.

(c) Two spoiler control relays and two time delay relays, located on the EPC forward center equipment panel, control the 115-vac power supply to the automatic actuator. Each spoiler control relay coil is connected electrically to one of the output channels on the anti-skid control box. The time delay relay coils are connected through the spoiler control relay contacts to the 28-vdc power supply. The relays along with dual indicating lights on the system engineer's control panel, form a lockout and spoiler inoperative indicator light circuit. In the event that one of the control box channels fails, the circuit interrupts the 115-vac power supply to the automatic actuator and completes a 28-vdc circuit causing both spoiler inoperative indicator lights to come on. A press-to-test switch is included in the circuit. The switch has three positions: the center position is the normal off position, the other two positions are used to test the individual light circuits.


AUTOMATIC ACTUATOR
EXTEND LIMIT SWITCH
RETRACT LIMIT SWITCH
MAIN LANDING GEAR SPOILER INOPERATIVE DUAL INDICATOR
28 VDC
28 VDC
INDICATOR TEST SWITCH
NO. 2
NO. 1
SPOILER CONTROL RELAYS
NO. 2
NO. 1
SPOILER LOCKOUT NO. 2 TIME DELAY RELAY 2.5 SECOND DELAY
115 VAC
ENGINE 3 GROUND CONTROL RELAY
SPOILER LOCKOUT NO. 1 TIME DELAY RELAY 2.5 SECOND DELAY
ENGINE 1 GROUND CONTROL RELAY
ANTI-SKID CONTROL BOX
NO. 1 MISC GROUND CONTROL RELAY
LEFT LANDING GEAR
RIGHT LANDING GEAR
WHEEL SPEED TRANSDUCERS

FTX80283

SPOILER CONTROL SYSTEM -- ELECTRICAL SCHEMATIC
Figure 27-71

(d) The anti-skid control box, located on the accessory compartment, contains two electronic switching circuits. Each circuit or channel consists of two inputs, an amplifier circuit, and one output. The inputs are connected electrically to the wheel speed transducers. When one of the input signals has reached the proper frequency, the signal is amplified and applied to the output. The output of each channel is applied to the coil of one of the spoiler control relays.

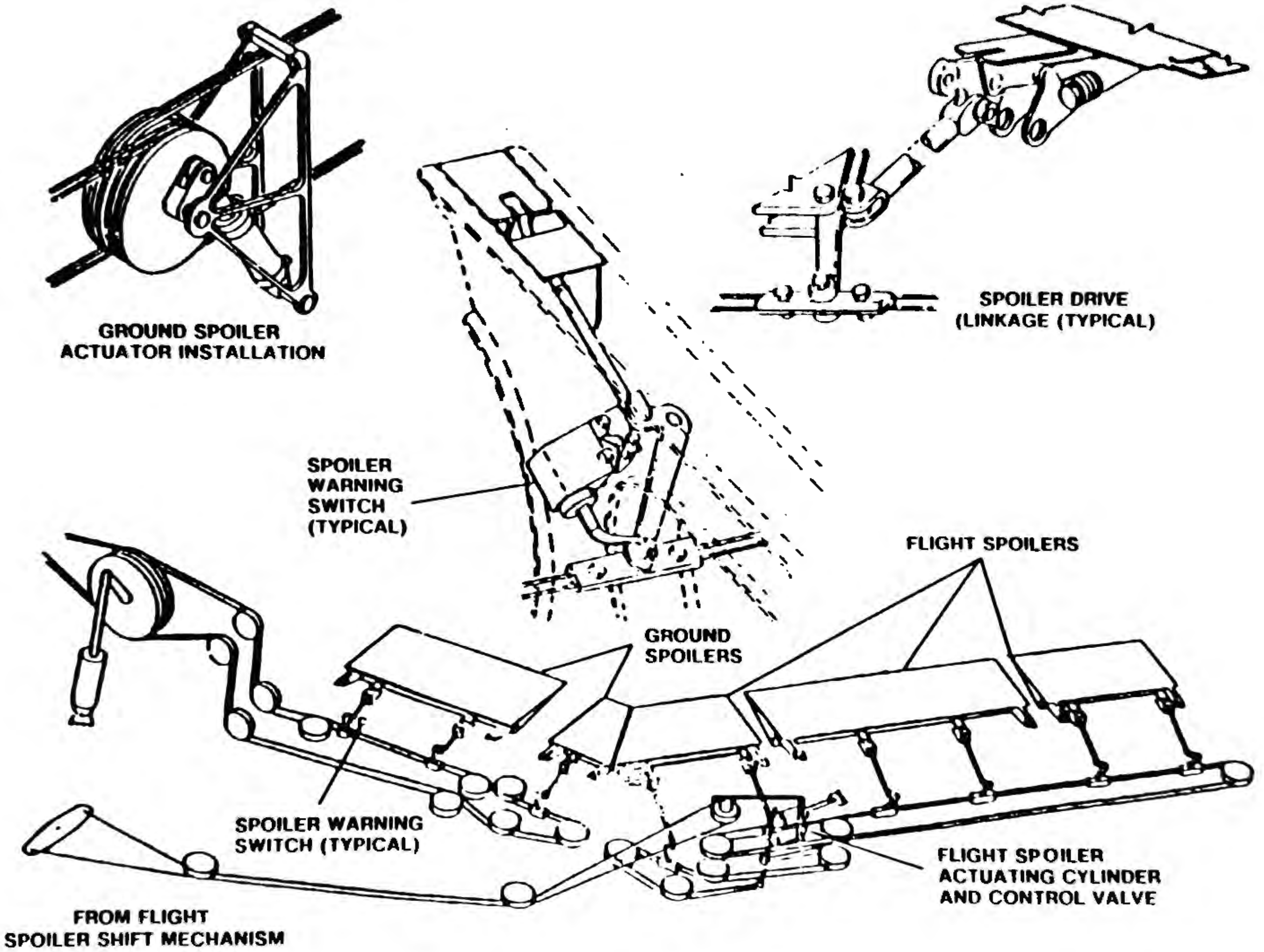
(4) Spoiler Mechanical Actuating System (See Figure 27-72)

(a) The spoiler mechanical actuating system consists of the cable systems and mechanical linkages that are driven by the spoiler hydraulic components to extend and retract the spoiler panels. The system consists of the ground spoiler system and two lateral control spoiler cable systems.

(b) The ground spoiler actuating cylinder piston rod is connected by mechanical linkage to a cable drum in the left wheel well. This cable drum is connected by a cable system to another cable drum located forward of the outboard ground spoiler panel on the left wing. The drive linkages of the ground spoiler panels are clamped to the cable loop. A similar cable loop is installed in the right wing forward of the ground spoiler panels. The inboard cable drum in each loop is interconnected by a cable system so that the actuating cylinder operates both cable loops simultaneously.

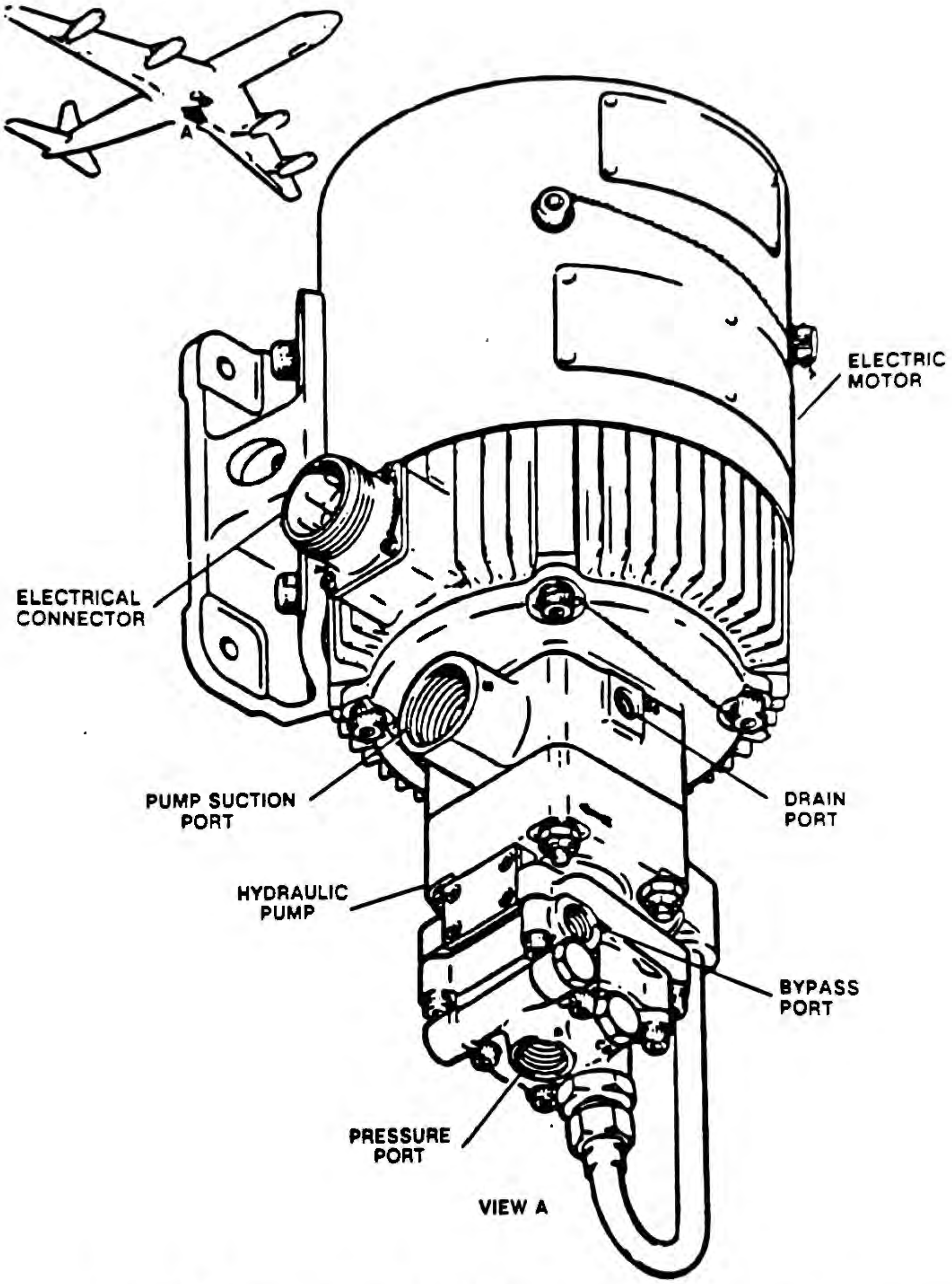
(c) Each lateral control spoiler power cylinder piston rod is attached to the wing structure. The power cylinder housing is connected by mechanical linkage to cable loop which is routed around cable drums forward of the lateral control spoiler panels. The drive linkages of each lateral control spoiler panel are clamped to the cable loop.

Figure 27-72


GROUND SPOILER ACTUATOR INSTALLATION
SPOILER DRIVE (LINKAGE (TYPICAL)
SPOILER WARNING SWITCH (TYPICAL)
FLIGHT SPOILERS
GROUND SPOILERS
SPOILER WARNING SWITCH (TYPICAL)
FLIGHT SPOILER ACTUATING CYLINDER AND CONTROL VALVE
FROM FLIGHT SPOILER SHIFT MECHANISM

SPOILER MECHANICAL CONTROL

FTX80280



SPOILER HYDRAULIC SYSTEM -- HYDRAULIC PUMP FTX80285
Figure 27-74

B. Operation

(1) Lateral Control Spoilers

(a) When used as an aid to lateral control, the three outboard spoiler panels on each wing are controlled by the aileron control wheels. When the main landing gear is extended during low-speed flight, the cable system from the main gear torque tube actuates the main gear actuated shift mechanism to shift control of the lateral control spoiler panels to the aileron control system.

(b) As the aileron control wheels are rotated, the aileron control system cables rotate the sector in the shift mechanism. When the ailerons have traveled approximately 8 degrees from the faired position, the sector operates the control linkage in the shift mechanism, rotating the bellcrank that is connected to the lateral control spoiler control valve on the same wing as the upgoing aileron. The control valve directs hydraulic pressure to the power cylinder to extend the panels on that wing. The panels on the opposite wing remain in the retracted position.

(2) Ground Spoilers

(a) The ground spoiler controls may be operated manually or may be set to operate automatically when the main landing gear wheels spin on touchdown. In either case, all five spoiler panels on each wing are extended simultaneously.

(b) For automatic operation, the spoiler control lever is set in an armed position during flight. The control lever cannot be set in the armed position unless the nose gear oleo strut is fully extended and the automatic actuator is in the retract position. This prevents the lever being set for automatic operation prior to takeoff. When the nose gear oleo strut is extended, a 28-vdc circuit is completed through the contacts of one of the ground control relays and the contacts of the automatic actuator retract limit switch to the actuator motor. This reverses the phase of the motor and the actuator moves to the retract position. When the motor reaches the limit of travel, the retract limit switch contacts are opened and the extend limit switch contacts are closed, cutting off power to the motor.

(c) With the actuator in this position, the spoiler control lever can be set in the armed position for automatic operation. No action occurs until the switching circuits in the anti-skid control box are triggered or until the nose gear oleo strut is compressed. The control box has two switching circuits, each triggered by the highest of two signal frequencies received from sensors in the wheel speed transducers which are located in the hubs of the main landing gear wheels. These sensors send signals to the control box when the wheels spin on contact with the ground. When both wheels on one side, both inboard wheels, or both outboard wheels spin at approximately 750 rpm, the control box switching circuits are triggered, the signal is amplified to 28-vdc, and applied to the coils of the spoiler control relays. This completes a 115-vac circuit through the contacts of the spoiler control relays to the actuator motor.

(d) The actuator motor rotates the output shaft, causing the mechanical linkage to drive the spoiler control lever aft. The control lever operates the cable system to the ground spoiler control valve causing the control valve to direct hydraulic pressure to the ground spoiler actuating cylinder. The actuating cylinder piston extends, driving the ground spoiler actuating cable system to extend the inboard spoiler panels on each wing. At the same time, mechanical linkage from the left inboard ground spoiler cable drum actuates the control linkage in the shift mechanism to operate the lateral control spoiler control valves. Both lateral control spoiler control valves direct hydraulic pressure to the corresponding power cylinder. The power cylinder piston rods extend, causing the lateral control spoiler actuating cable systems to extend the three outboard spoiler panels on each wing.

(e) Two separate lockout and spoiler inoperative indicator light circuits provide visual indication and interrupt the power supply to the automatic actuator in the event of a failure in one of the channels from the anti-skid control box. If only one spoiler control relay is energized by the output from the control box, two separate 28-vdc circuits are completed, one to energize the coil of each time delay relay. If the inoperative spoiler control relay is not energized within 2.5 seconds, each time delay relay completes a 28-vdc circuit, thus causing both spoiler inoperative indicator lights to come on. The 115-vac power supply to the automatic actuator is through the normally closed contacts of each time delay relay, so that when the relay is energized, power is cut off from the actuator. Each time delay relay has a latching circuit so that once the relay is energized, it remains energized regardless of the position of the spoiler control relays.

(f) The ground shift mechanism acts as a backup system if the main gear actuation is inoperative. With the spoiler control lever in the armed position, when the nose gear oleo strut is compressed on landing, the nose gear upper torque link actuates the ground shift mechanism. The cables from the ground shift cable drum rotate the sector in the control pedestal. Mechanical linkage form the sector drives the spoiler control lever aft to operate the ground spoiler controls in the same manner as in normal automatic operation. The spoiler panels are retracted by manually moving the spoiler control lever to the retract position.

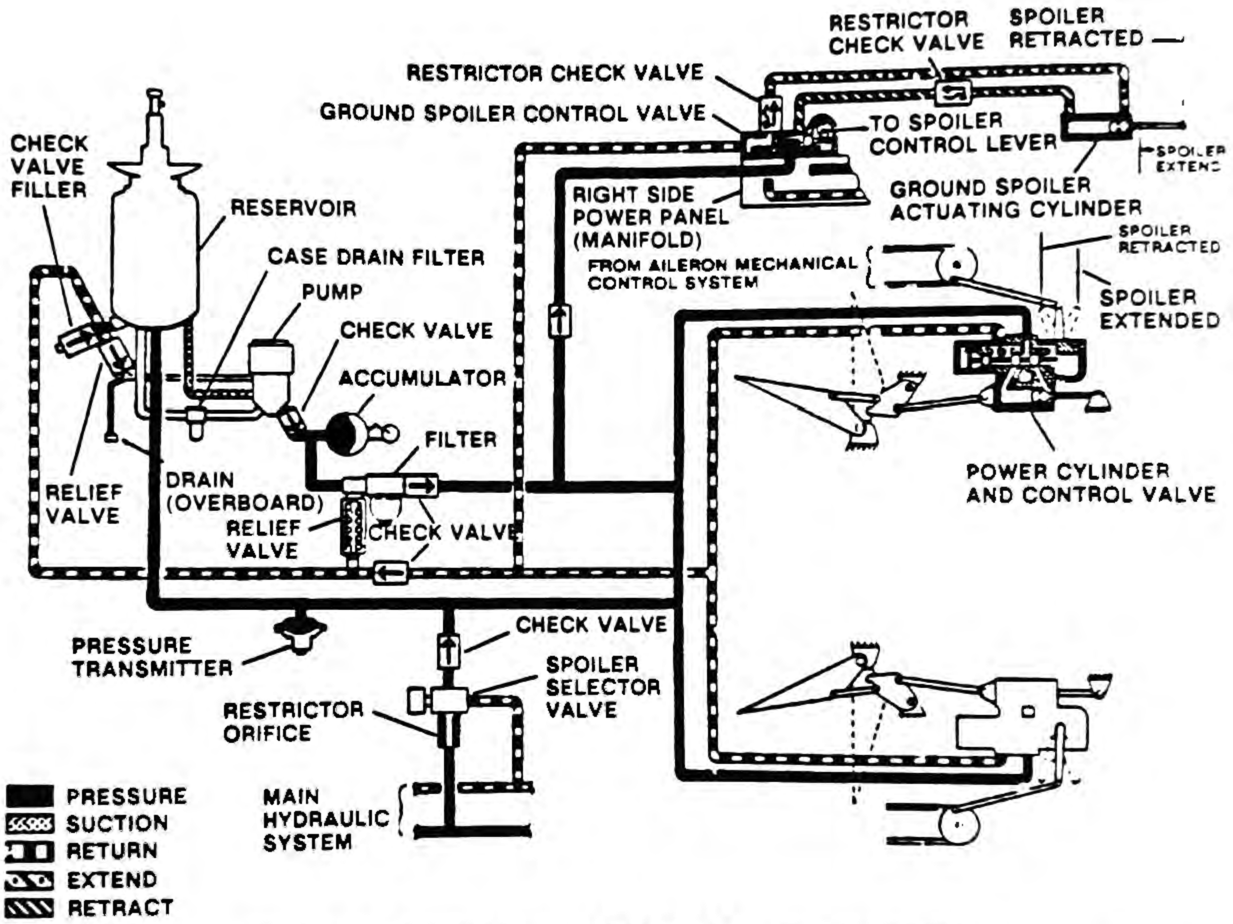
(g) Manual operation of the ground spoiler can be accomplished by moving the spoiler control lever to the extend position when the nose gear strut is compressed. The spoiler cable system and the hydraulic controls are actuated in the same manner as during automatic operation.

(h) If, after initial touchdown and after the ground spoiler have operated, it should become necessary to immediately take off again, the spoiler panels are automatically retracted as soon as the engine throttles are advanced for takeoff. The spoiler control lever is mechanically interconnected with No. 4 engine throttle so that as the throttle is advanced, the spoiler control lever is moved from the armed position and the spring loaded ground spoiler hydraulic control valve returns to the spoiler retract position.

23. Spoiler Hydraulic System - Description and Operation

A. General (See Figure 27-73)

(1) The spoiler hydraulic system is an independent system that applies hydraulic pressure to operate the lateral control and ground spoiler panels. The main hydraulic power system is connected through a solenoid operated selector valve to provide a standby method of pressurizing the spoiler system.



SPOILER HYDRAULIC SYSTEM -- SCHEMATIC

FTX80284

Figure 27-73

(6) Ground Spoiler Actuating Cylinder

(a) The ground spoiler actuating cylinder, located on the keel web in the left wheel well, actuates the ground spoiler cable systems in the wings to extend and retract the ground spoiler panels.

(b) The actuating cylinder consists of a cylinder, piston, and a piston rod end. The cylinder is attached to a bracket mounted on the keel web. The piston rod end is connected by mechanical linkage to the spoiler cable systems. Hydraulic lines connect the cylinder ports to the ground spoiler control valve.

(7) Lateral Control Spoiler Power Cylinder and Control Valve (See Figure 27-78)

(a) There are two power cylinder and control valve assemblies, one located adjacent to the outboard drive linkage on each inboard lateral control spoiler. Each assembly consists of a power cylinder, control valve, and swivel gland.

(b) The power cylinder piston rod end is attached to the wing closing spar structure. The cylinder housing is connected by mechanical linkage to the lateral control spoiler cable system in the wing.

(c) The control valve, mounted on the power cylinder, consists of a spring-loaded slide valve and a control lever. Internal passages in the assembly connect the control valve pressure outlets with the power cylinder inlets. Pressure inlet and return ports on the control valve are connected to the swivel gland, which acts as a flexible connection to the spoiler hydraulic system lines. The control valve control lever is connected by mechanical linkage through a mechanical shift and control mechanism to the aileron control wheel cable system and the ground spoiler cable system.

(8) Spoiler Hydraulic System Filter

(a) A 10-micron hydraulic line filter is installed in the spoiler hydraulic system downstream of the pump and pressure accumulator.

(2) The spoiler hydraulic system consists of the following major components: an electric-driven hydraulic pump, reservoir, accumulator, selector valve, ground spoiler control valve, ground spoiler actuating cylinder, lateral control power cylinder and control valve, filter, relief valve, and check valves.

B. Component Description

(1) Spoiler Hydraulic System Hydraulic Pump (See Figure 27-74)

(a) The spoiler hydraulic system pump, located in the aft section of the right main gear wheel well, supplies hydraulic pressure for the spoiler hydraulic components. The pump unit consists of an electric motor and a hydraulic pump.

(b) The electric motor is a 115/200-volt, 3-phase, 400-cps, continuous duty motor mounted directly on top of the hydraulic pump. The motor rotor has internally splined output shaft which fits on the externally splined drive shaft of the pump. The motor is connected electrically to the flight spoiler switch in the flight compartment.

(c) The hydraulic pump is a variable displacement pump comprised of the following major parts: a four piece housing, cylinder and piston group, pivoting hanger with an inclined camface, hold down plate, pressure compensating valve, and bearings.

(d) When the electric motor is actuated, the drive shaft rotates the cylinder and piston group. Each revolution of the cylinder causes one complete stroke of each piston. The pistons are held against the camface of the hanger by the hold down plate, providing positive piston return. The displacement of fluid from the pump discharge port is controlled by the pressure compensating valve. The pump delivers full flow of 3.9 gpm at system pressures up to approximately 2700 psi. At this point, the compensating valve reduces flow until at approximately 3000 psi, the displacement of fluid is decreased to zero.

(2) Spoiler Hydraulic System Reservoir (See Figure 27-75)

(a) The spoiler hydraulic system reservoir, located on the aft bulkhead in the right wheel well, is a cylindrical tank enclosed in a corrugated protective shield. The reservoir stores a supply of hydraulic fluid for use in the spoiler hydraulic system. The reservoir has a fluid capacity of approximately 1.2 US gallons. The reservoir consists of a tank, protective shield, piston, diaphragm assembly, and a barrel guide. A scupper, sight gage, and a bleed valve are located on the upper end of the barrel guide.

(b) The reservoir supplies hydraulic fluid under pressure to the spoiler hydraulic pump. When the spoiler hydraulic system is pressurized, the diaphragm is forced down against the fluid in the reservoir, pressuring the supply to the pump. When system pressure is 3000 psi, pressure in the pump supply line is approximately 28.7 psi.

(3) Spoiler Hydraulic System Accumulator (See Figure 27-76)

(a) The spoiler hydraulic system accumulator, located in the aft inboard section of the right wheel well, absorbs surges of hydraulic pressure in the system, caused by pressure fluctuations, and supplies supplementary pressure for the system for limited periods of peak demand.

(b) The accumulator is a spherical pressure chamber with a flexible inner bladder. The accumulator is equipped with an air valve and a direct reading pressure gage. The gage indicates the pressure within the accumulator. The bladder is inflated with a 2000-psi initial charge of dry, compressed air, through the air valve. The outer chamber contains hydraulic fluid and is connected to the system pressure line. As hydraulic system pressure builds up, fluid enters the chamber and the air within the bladder is further compressed. When system pressure drops, the compressed air in the bladder forces the fluid out of the chamber.

(b) The filter consists of a housing, filter head, filter bowl, and a replaceable filter element. A magnetic drain plug at the base of the housing can be removed for cleaning without loss of hydraulic pressure.

(9) Spoiler Hydraulic Pump Case Drain Filter

(a) A 10-micron hydraulic line filter is installed in the pump case drain line downstream of the finned tubing which is installed for additional cooling of hydraulic fluid.

(b) The filter consists of a housing, filter head, filter bowl, and a replaceable filter element. A magnetic drain plug at the base of the housing can be removed for cleaning without loss of hydraulic pressure.

(10) Check Valves and Restrictor Valves

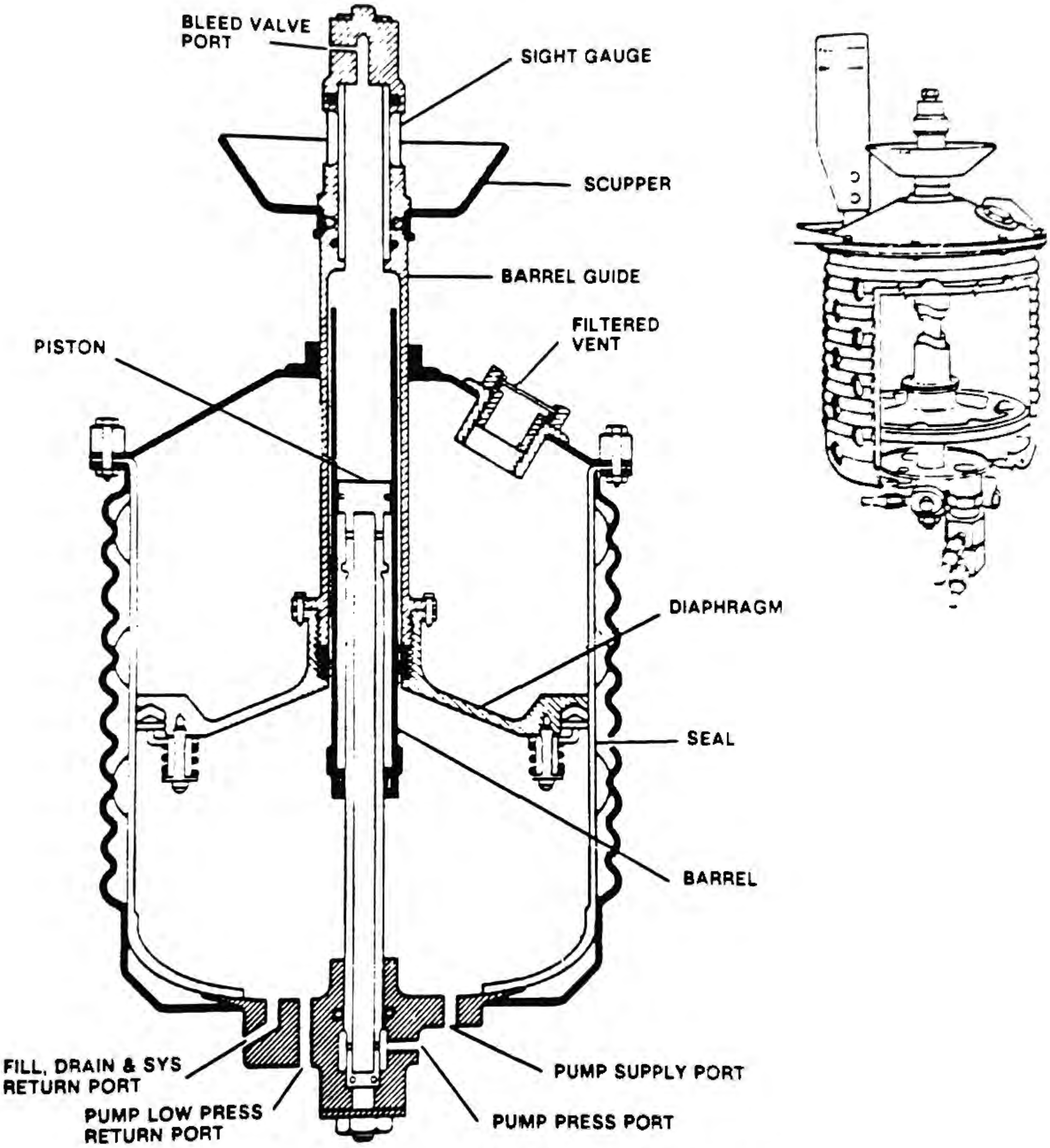
(a) There are two restrictor valves and five 1-way check valves installed in the spoiler hydraulic system. The restrictor valves are installed in the pressure lines between the ground spoiler control valve and the ground spoiler actuating cylinder. The restrictor valves allow free fluid flow in the spoiler extend direction, but restrict the flow in the retract direction.

(b) The check valves control the direction of flow through the system lines and prevent back surges of pressure.

(11) Spoiler Hydraulic System Electrical Components (See Figure 27-79)

(a) The spoiler hydraulic system electrical components consist of a flight spoiler switch, limit switch, spoiler hydraulic pump relay, pressure transmitter, and a pressure indicator.

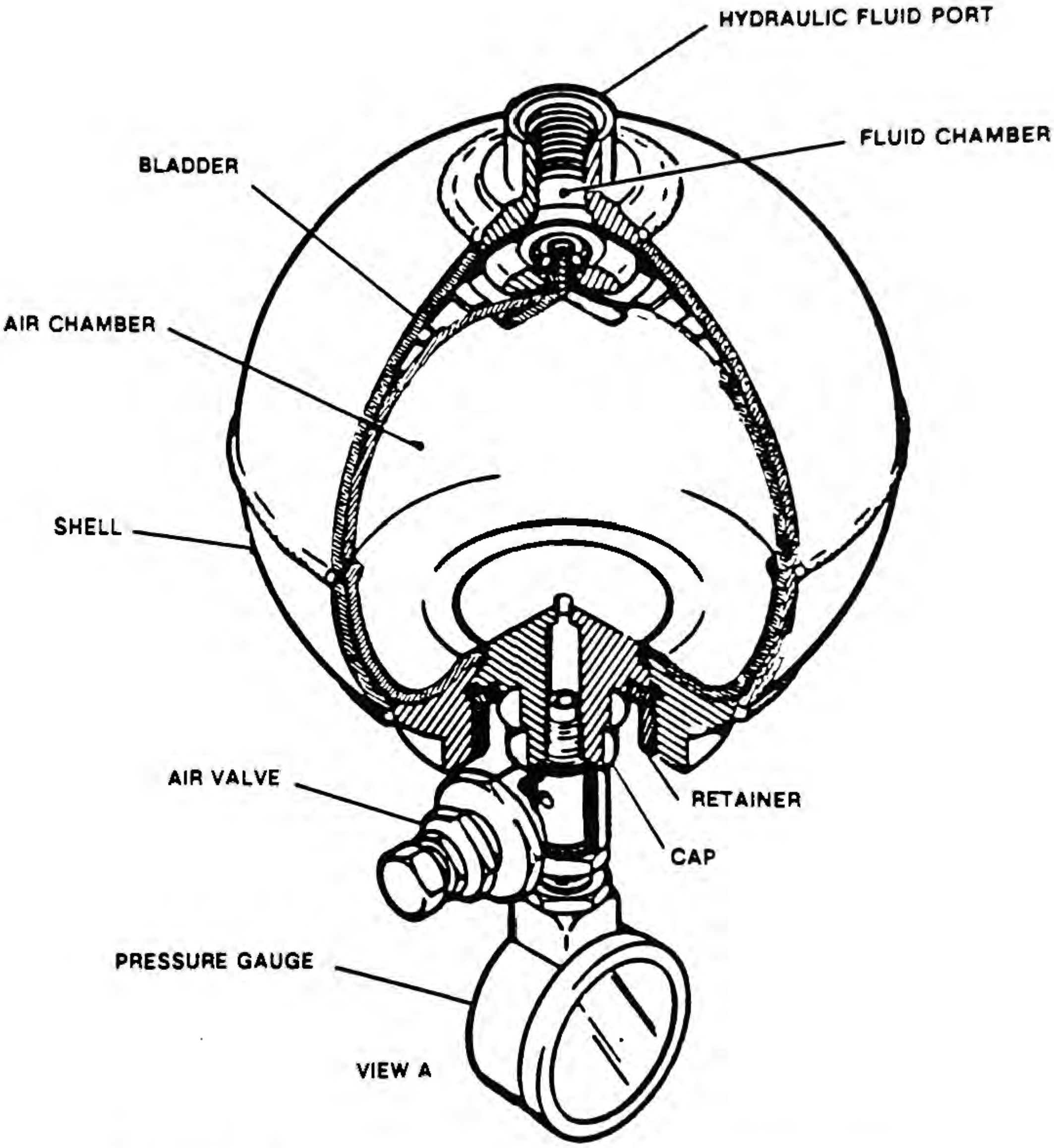
(b) The flight spoiler switch, located in the flight compartment, has three positions. The normal and off positions are positive positions, but the override position is a momentary contact position. The limit switch, located in the left wheel well, is actuated by the extension of the landing gear.



GND & FLT SPOILER HYD RESERVOIR

FTX80286

Figure 27-75



SPOILER HYDRAULIC SYSTEM -- ACCUMULATOR FTX80287

Figure 27-76

(4) Spoiler Hydraulic Power Selector Valve

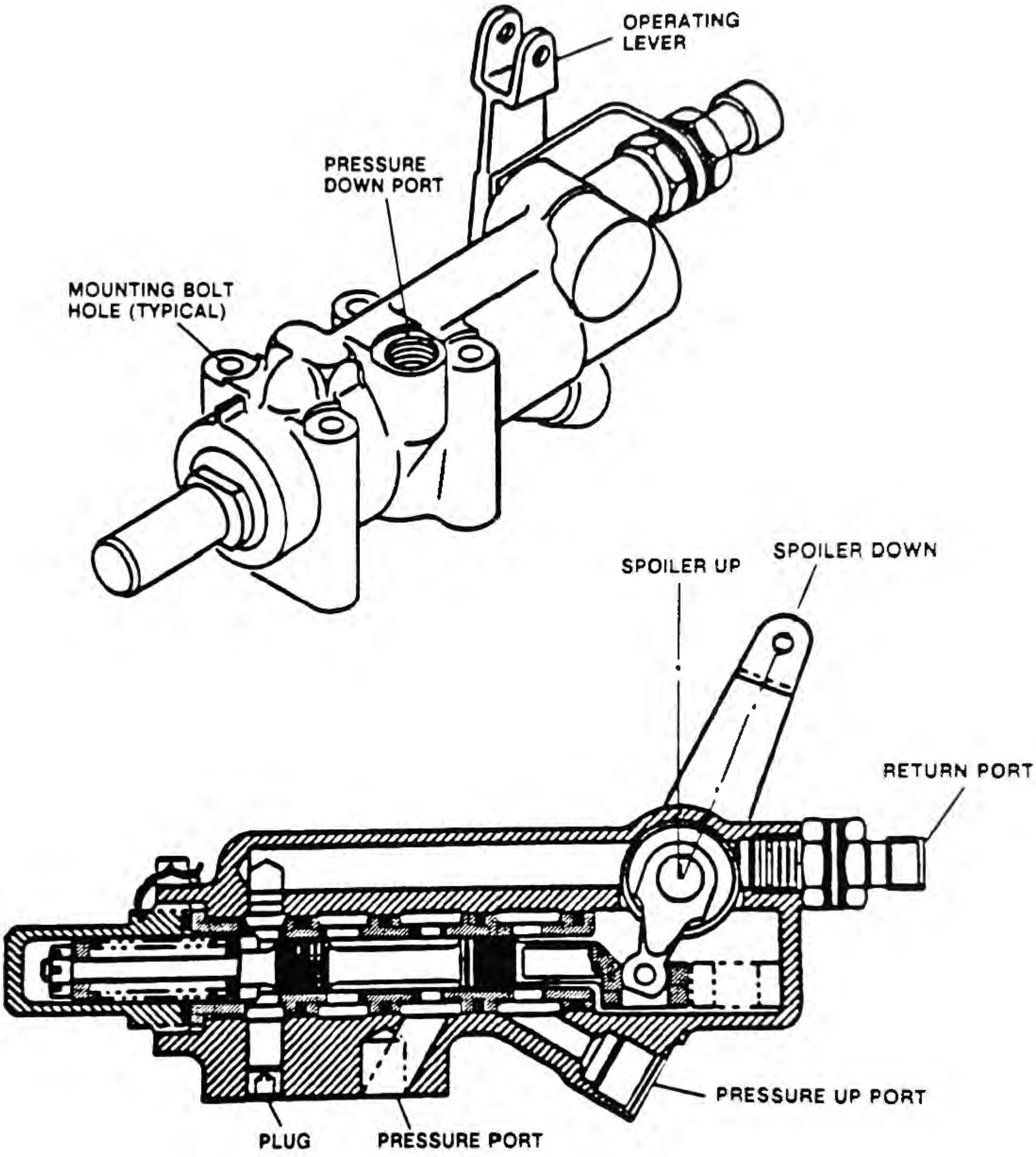
(a) The selector valve, located on the keel web in the left wheel well, provides a means of connecting the main hydraulic power system to the spoiler hydraulic power system during ground operation. The valve is a normally closed, solenoid-operated hydraulic valve. The solenoid is connected electrically to the 28-vdc power supply through the contacts of a ground control relay and the ground spoiler power switch.

(b) If the ground spoiler power switch is moved to the alternate position when the ground control relays are energized, the solenoid will open the selector valve, allowing the main hydraulic system to pressurize the normally isolated spoiler hydraulic system.

(5) Ground Spoiler Control Valve (See Figure 27-77)

(a) The ground spoiler control valve, located on the right hydraulic manifold in the right wheel well, controls the supply of hydraulic pressure to the ground spoiler actuating cylinder. The control valve consists of a housing, spring-loaded slide valve, and an operating lever. A pressure inlet and a return port are connected to the spoiler hydraulic system lines. Pressure outlet ports are connected by hydraulic lines to the ground spoiler actuating cylinder. The operating arm is connected by mechanical linkage and cables to the spoiler control lever on the pilot's control pedestal.

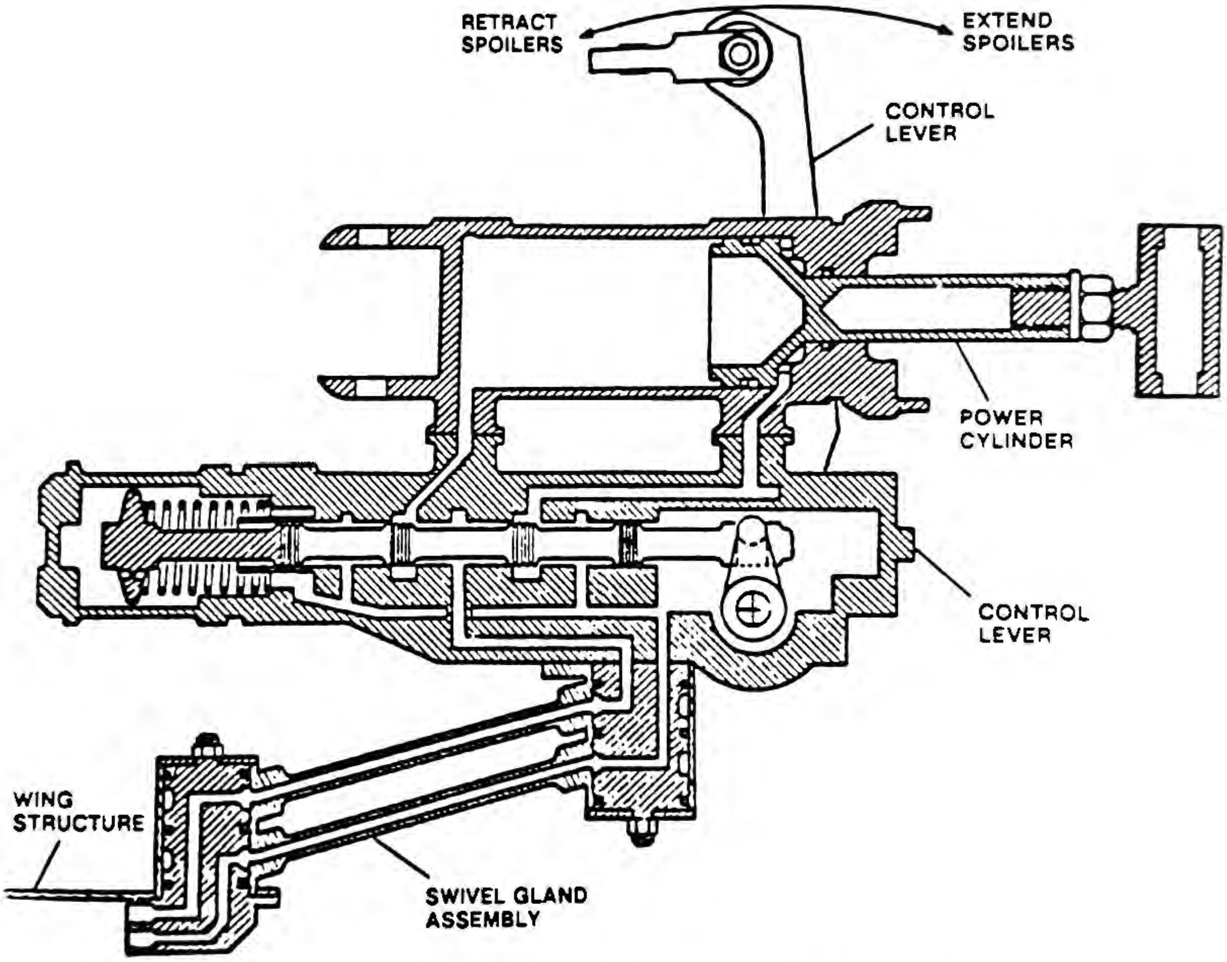
(b) When the operating lever is moved, the slide valve is positioned to direct hydraulic pressure to the corresponding side of the actuating cylinder.



SPOILER HYDRAULIC SYSTEM -- GROUND SPOILER CONTROL VALVE

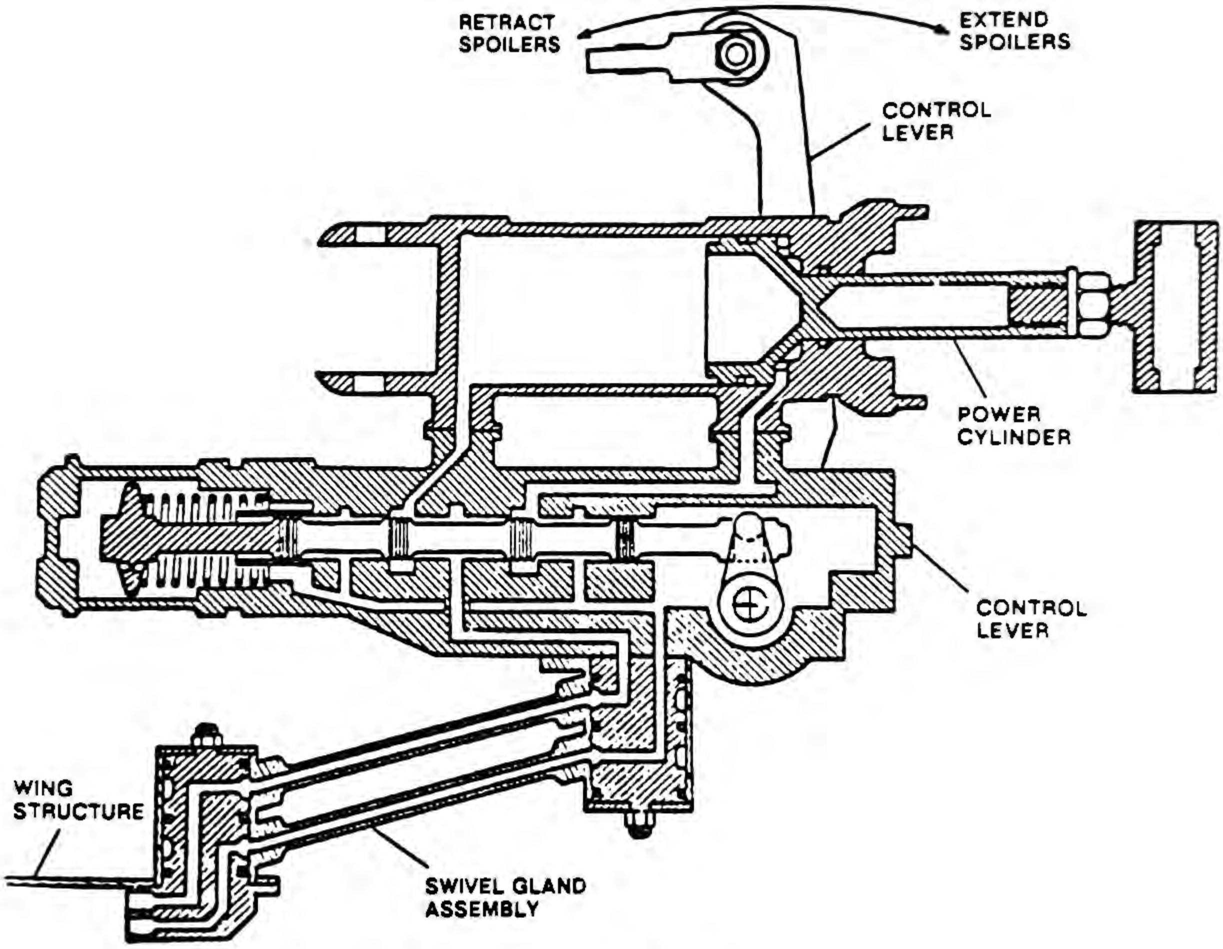
FTX80288

Figure 27-77



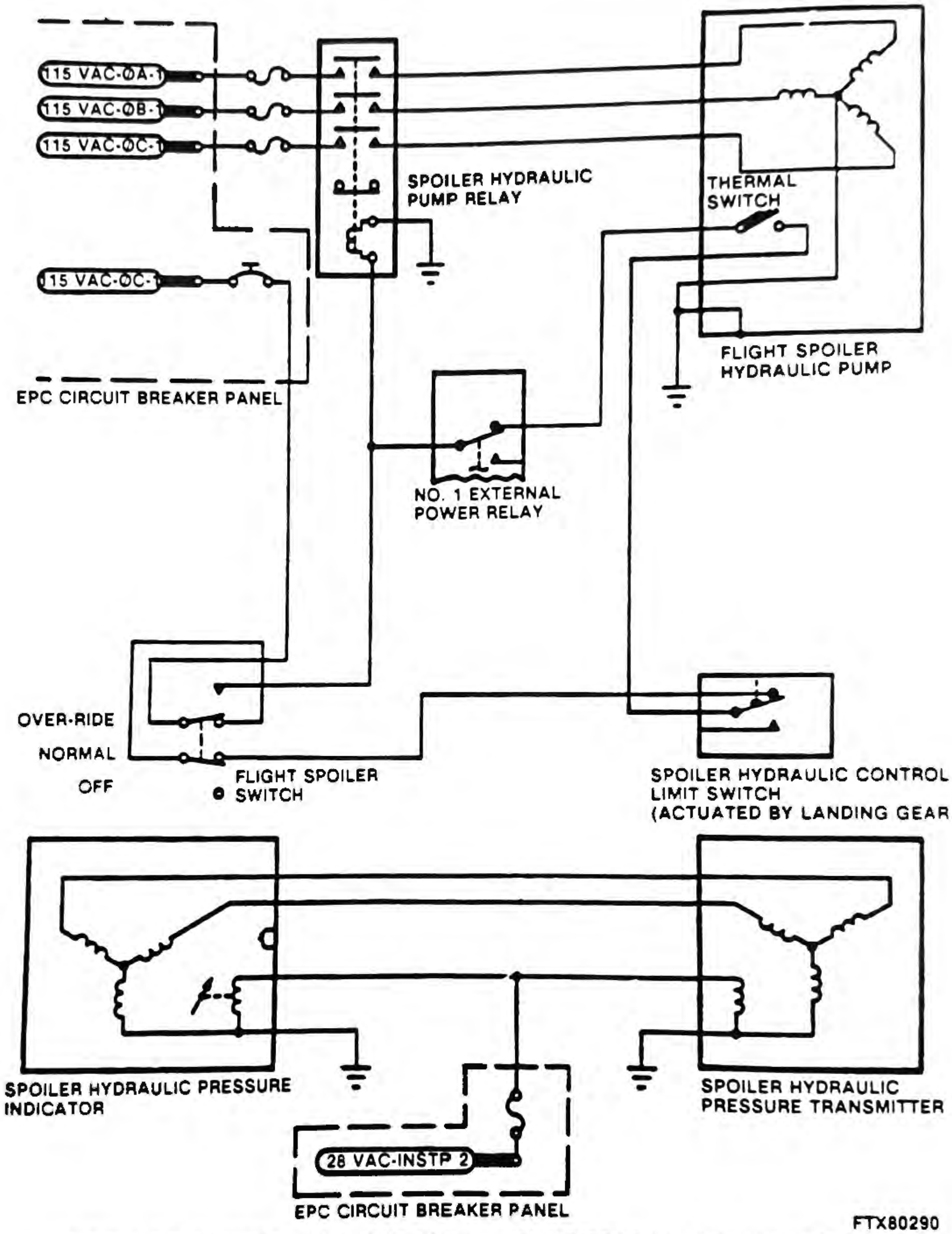
SPOILER HYDRAULIC SYSTEM -- LATERAL CONTROL SPOILER POWER CYLINDER AND CONTROL VALVE -- SCHEMATIC FTX80289

Figure 27-78



SPOILER HYDRAULIC SYSTEM -- LATERAL CONTROL SPOILER POWER CYLINDER AND CONTROL VALVE -- SCHEMATIC FTX80289

Figure 27-78


115 VAC-ØA-1
115 VAC-ØB-1
115 VAC-ØC-1
115 VAC-ØC-1
SPOILER HYDRAULIC PUMP RELAY
THERMAL SWITCH
FLIGHT SPOILER HYDRAULIC PUMP
EPC CIRCUIT BREAKER PANEL
NO. 1 EXTERNAL POWER RELAY
OVER-RIDE
NORMAL
OFF
FLIGHT SPOILER SWITCH
SPOILER HYDRAULIC CONTROL LIMIT SWITCH (ACTUATED BY LANDING GEAR
SPOILER HYDRAULIC PRESSURE INDICATOR
SPOILER HYDRAULIC PRESSURE TRANSMITTER
28 VAC-INSTP 2
EPC CIRCUIT BREAKER PANEL
FTX80290

SPOILER HYDRAULIC SYSTEM -- ELECTRICAL SCHEMATIC
Figure 27-79

(c) With the flight spoiler switch in the normal position, a 115-vac single phase circuit is completed to energize the spoiler hydraulic pump relay as soon as the landing gear is extended. When the spoiler hydraulic pump relay is energized, a 115-vac three phase circuit is completed through the relay contacts to the spoiler hydraulic pump motor. If the pump motor becomes overheated, a thermal switch which is an integral part of the motor, interrupts the single phase circuit to the relay. The relay becomes deenergized and cuts off power to the motor. The override position of the flight spoiler switch completes a circuit direct to the relay, bypassing the limit switch and the thermal switch, therefore the flight spoiler switch should never be held in the override position for periods in excess of five minutes or the pump motor may become over-heated. The off position of the flight spoiler switch completely isolates the circuit from the power supply.

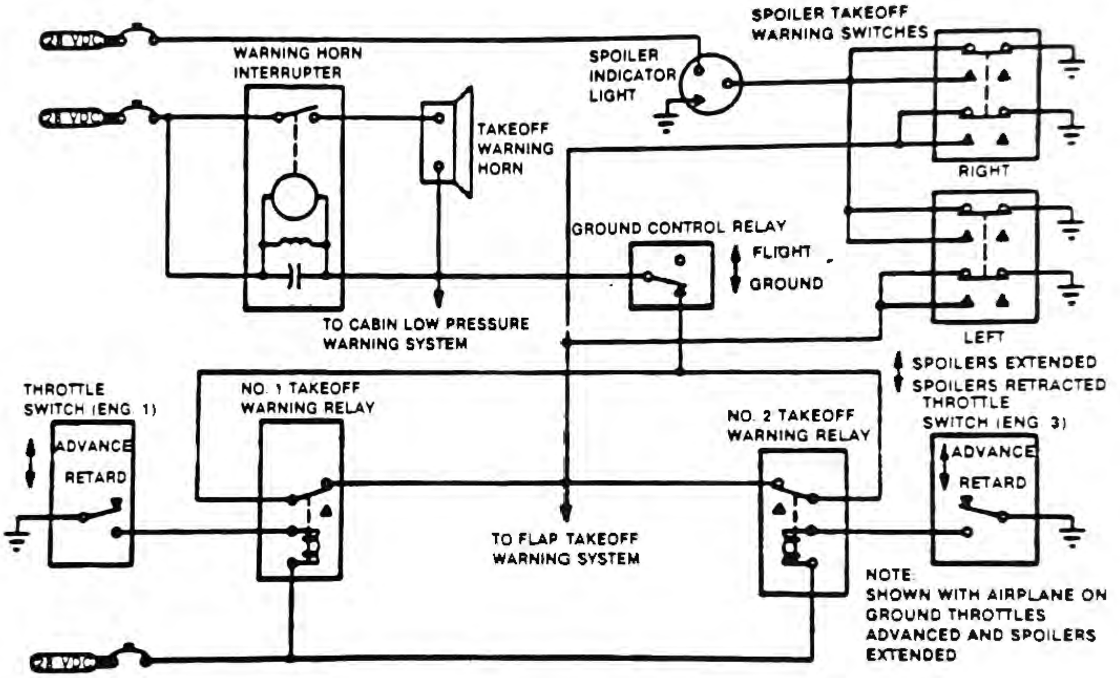
(d) The pressure transmitter, located in the right wheel well, is connected to the pressure indicator in the flight compartment to provide visual indication of the hydraulic pressure available to operate the spoiler system.

24. Spoiler Takeoff Warning System - Description and Operation

A. General (See Figure 27-80)

(1) The spoiler takeoff warning system is a mechanically actuated electrical system that provides an intermittent audible warning if the engine throttles are advanced for takeoff with the spoiler panels not in the retracted position. The system also causes an indicating light in the flight compartment to come on when the spoiler panels are not retracted.

(2) The takeoff warning system consists of two spoiler takeoff warning switches connected electrically to components of the takeoff warning and cabin low-pressure warning circuit. The switches are located adjacent to the inboard ground spoiler panel actuating linkage. Each switch has two sets of contracts: one included in the takeoff warning circuit and one included in the indicating light circuit.



NOTE:
SHOWN WITH AIRPLANE ON GROUND THROTTLES ADVANCED AND SPOILERS EXTENDED

SPOILER TAKEOFF WARNING SYSTEM -- SCHEMATIC FTX80304

Figure 27-80

B. Operation

(1) When the spoiler panels are not fully retracted, the takeoff warning switch contacts are closed by the spoiler actuating linkage. If the airplane is on the ground (ground control relays energized) and the No. 1 or No. 3 engine throttles are advanced for takeoff with the warning switch in this position, a 28-vdc circuit is completed, actuating the takeoff warning horn. The warning horn cannot be silenced unless the throttles are retarded or the spoiler panels retracted.

(2) When the spoiler takeoff warning switch contacts are closed, a second 28-vdc circuit is completed, causing a spoiler extend indicating light on the main instrument panel to come on. The spoiler indicating extend light is on when the spoiler panels are not retracted, regardless of the positions of the engine throttles or ground control relays.

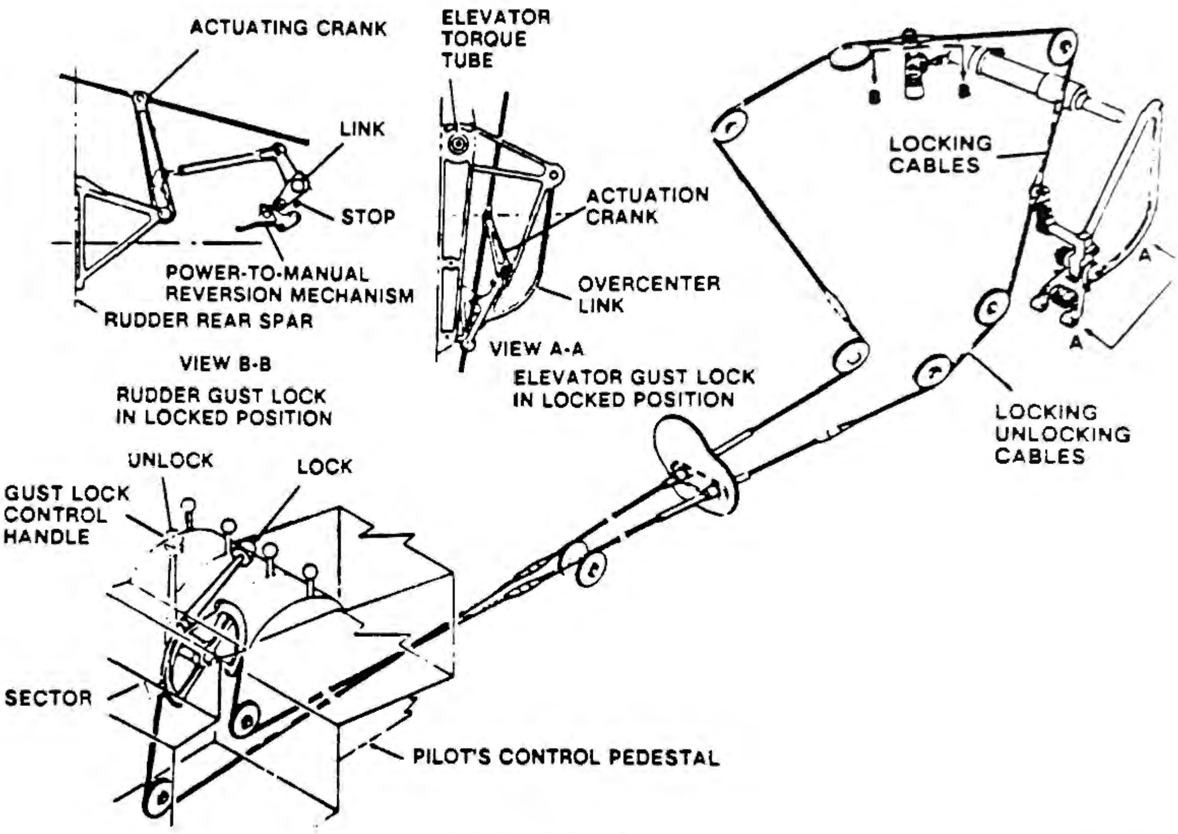
25. Gust Lock and Dampener - Description and Operation

A. General (See Figures 27-81 & 27-82)

(1) A gust lock system is provided to lock the rudder and elevator to prevent rapid movement of the surfaces due to sudden gusts of wind while the airplane is on the ground. The system consists of a gust lock control lever, a 2-way cable system, and the rudder and elevator gust lock linkages.

(2) The gust lock control lever, located on the pilot's control pedestal, is interlocked with the engine throttles to prevent the throttles being advanced when the control surfaces are locked. The interlock also prevents accidental engagement of the gust lock control lever when the throttles are in the advanced position during flight. The control lever is attached to a sector on the control pedestal main sector shaft. The 2-way cable system extends from the sector to the rudder and elevator gust lock actuating cranks in the empennage.

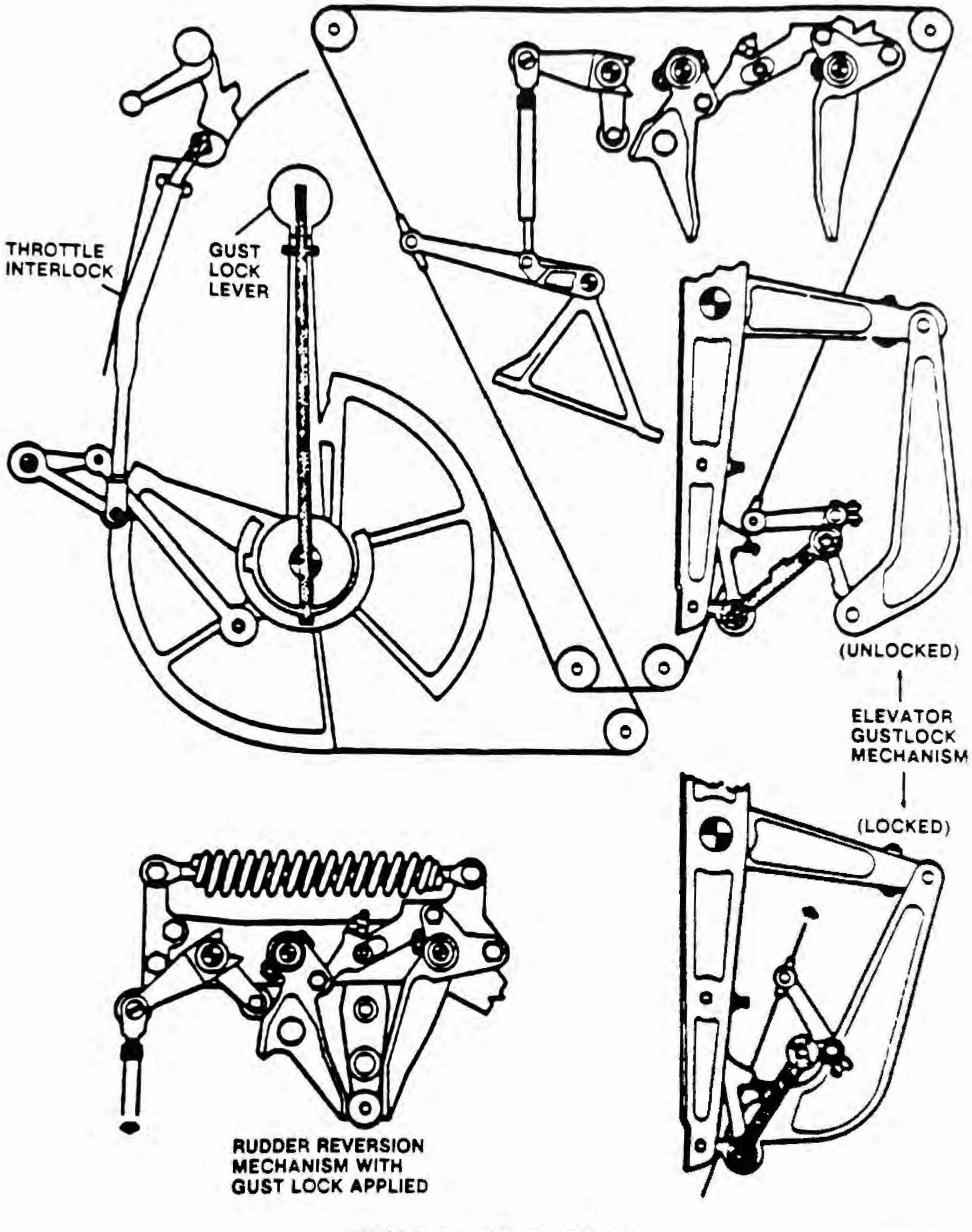
(3) The rudder gust lock actuating crank is connected by mechanical linkage to a stop on the rudder power-to-manual reversion mechanism. The elevator gust lock actuating crank is connected to an overcenter linkage on the elevator bus torque tube. The rudder and elevator gust lock linkages are spring-loaded to unlock in the event of a cable breakage.



GUST LOCK SYSTEM

FTX80291

Figure 27-81


THROTTLE INTERLOCK
GUST LOCK LEVER
(UNLOCKED)
ELEVATOR GUSTLOCK MECHANISM
(LOCKED)
RUDDER REVERSION MECHANISM WITH GUST LOCK APPLIED
FTX80292

GUST LOCK SYSTEM
Figure 27-82

B. Operation

(1) When the gust lock control lever is moved to the lock position, the cable system moves the elevator and rudder gust lock actuating cranks. The elevator gust lock actuating crank moves the elevator gust lock linkage to the overcenter position, locking the elevator. The elevator control tabs are not directly affected by the gust lock system, but are subject to the centering forces of the elevator load-feel mechanism.

(2) The rudder gust lock actuating crank moves the rudder gust lock linkage to lock the rudder power-to-manual reversion mechanism in the power on position. In this position, the rudder tab is locked in faired position and hydraulic fluid is prevented from bypassing through the rudder tab lockout cylinder. The rudder trim and load-feel mechanism, through the rudder control system, positions the rudder control valve in the neutral position so that hydraulic fluid is trapped in each side of the rudder power cylinder, thus preventing sudden rapid movement of the rudder.

26. Lift Augmenting - Description and Operation

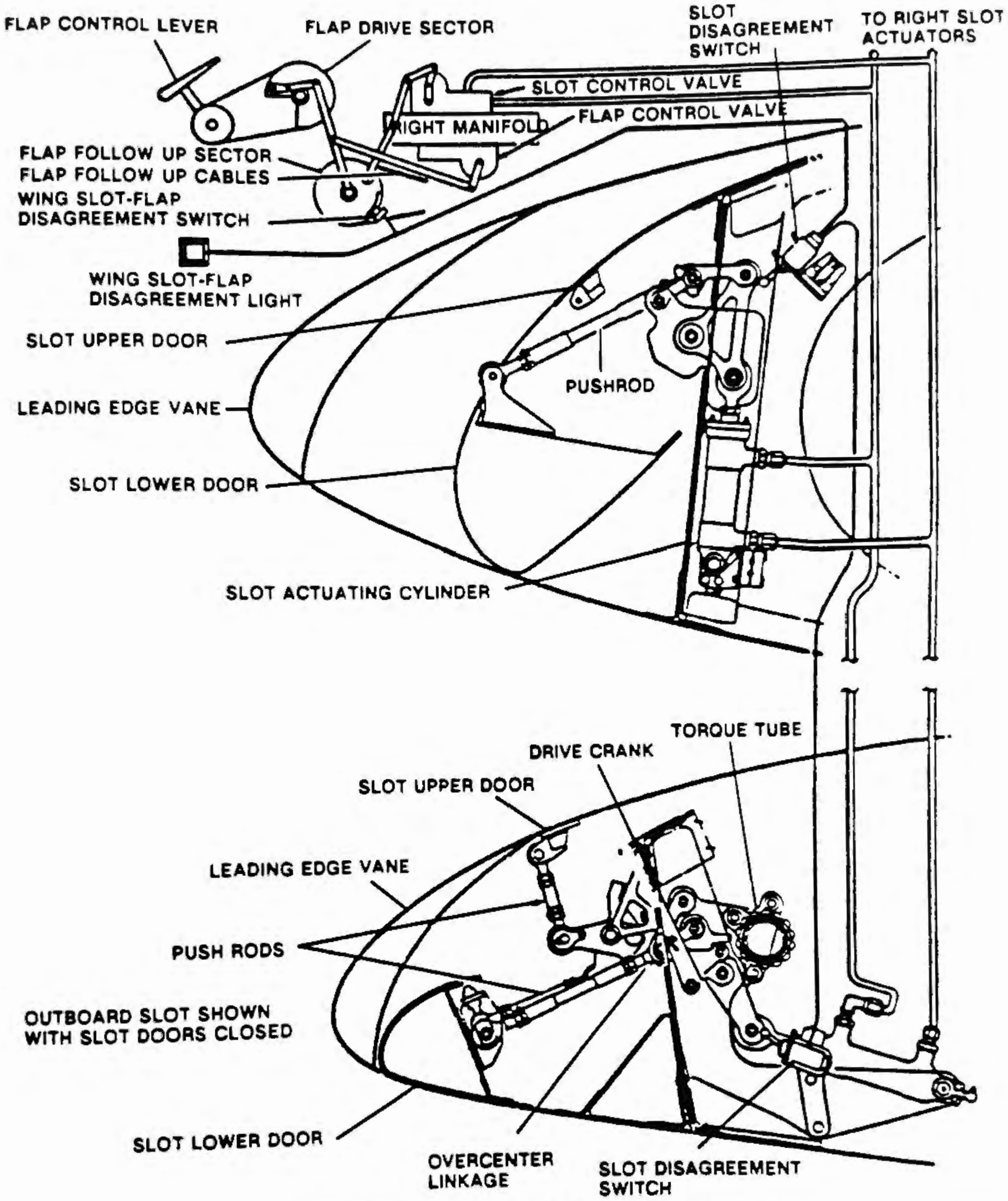
A. General (See Figures 27-83, 27-84 & 27-85)

(1) The wing leading edge slots augment the flaps in increasing the lift of the wing during landing and takeoff procedures. The wing slot system is a hydraulically actuated system controlled indirectly by the flap control lever on the pilot's control pedestal. The wing slot system consists of the inboard and outboard slot doors, four slot actuating cylinders, and the related mechanical linkage.

B. Component Description

(1) Wing Slot Doors

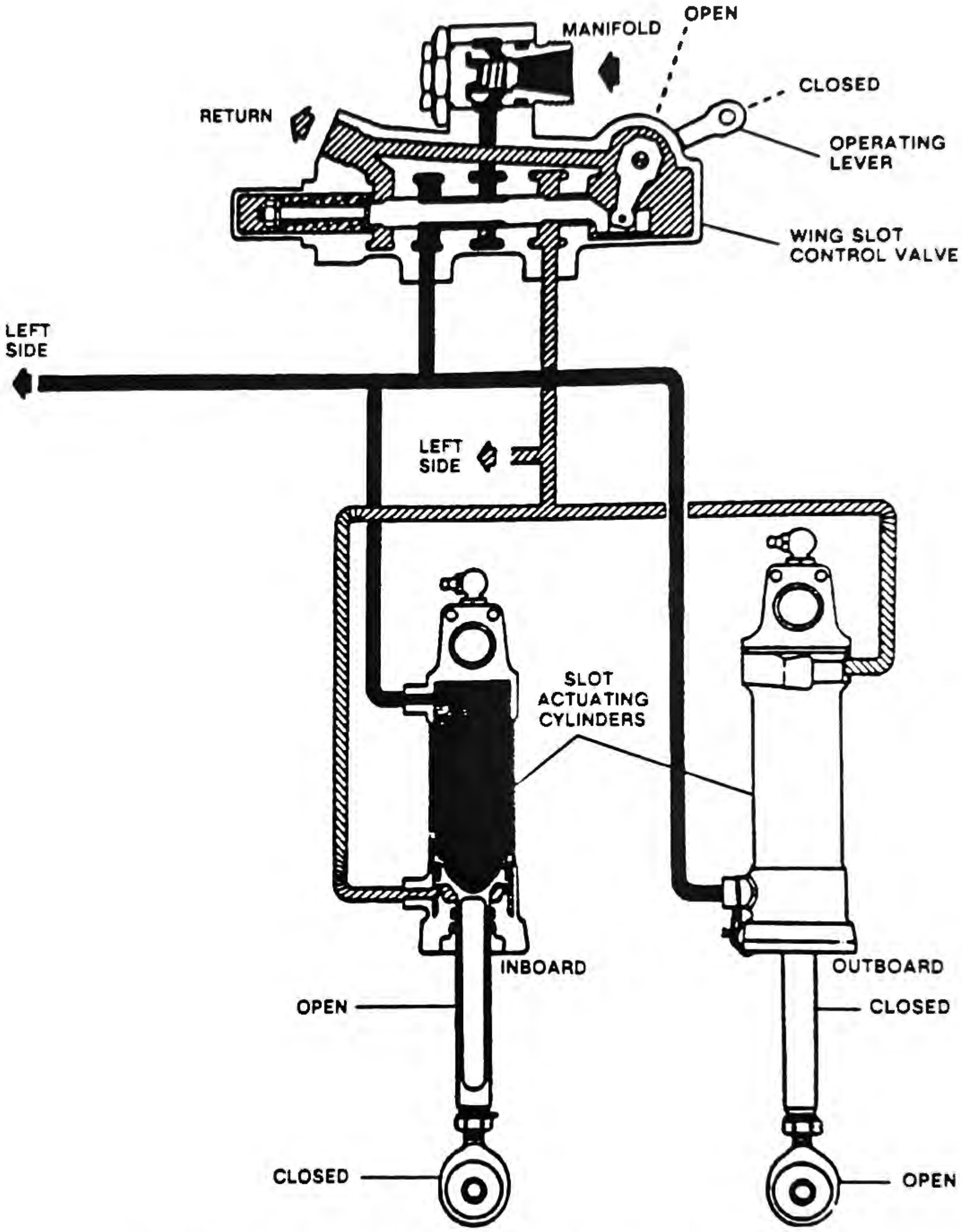
(a) Each wing slot has upper and lower slot doors. When closed, the doors fair with the wing leading edge vane and the upper and lower surfaces of the wing to complete the wing leading edge contour. When open, the doors fair with an island structure to complete the aft surface of the wing slot. The upper slot doors are



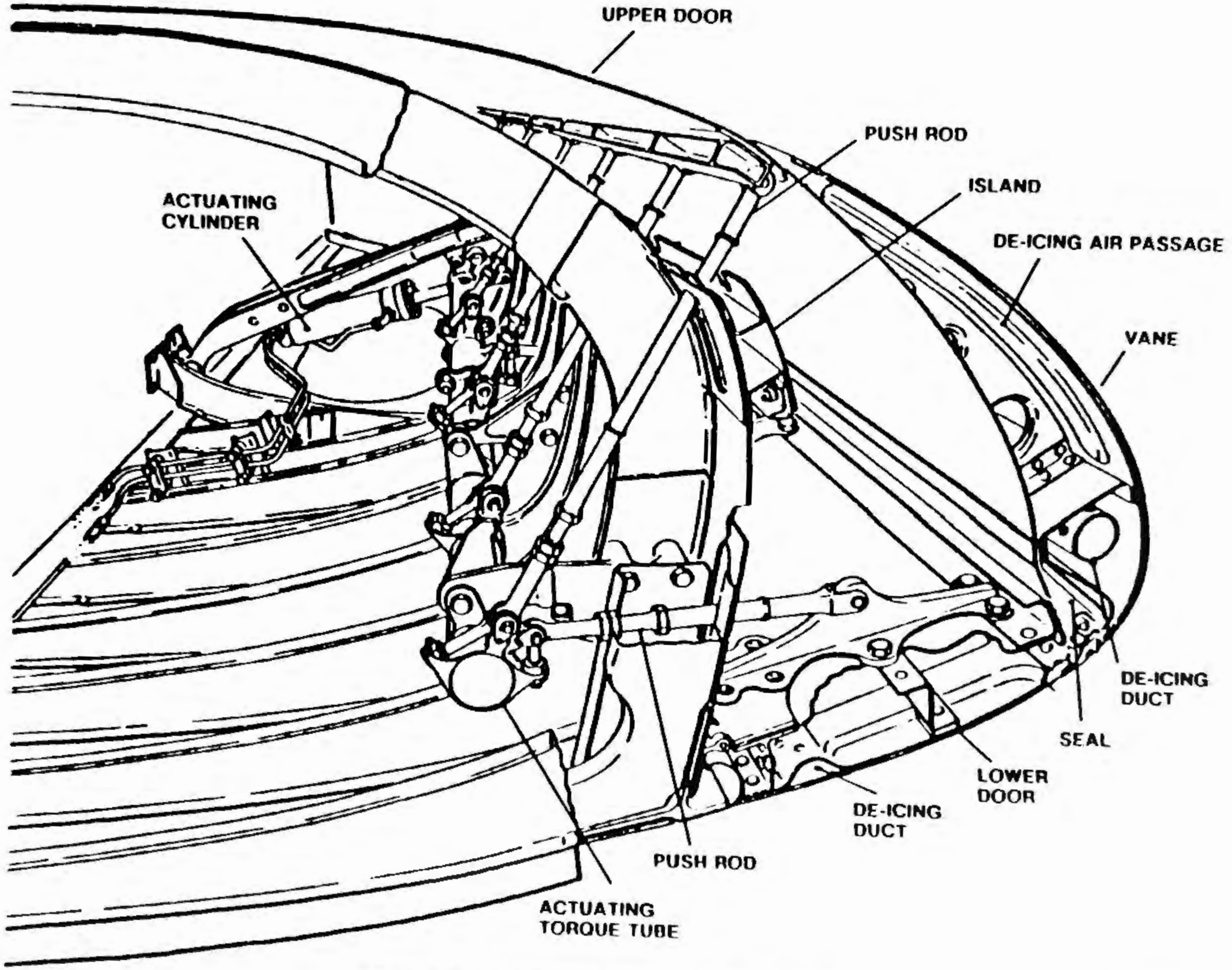
WING SLOT SYSTEM -- SCHEMATIC

FTX80293

Figure 27-83



WING SLOT SYSTEM -- HYDRAULIC SCHEMATIC FTX80294
Figure 27-84



WING SLOT MECHANICAL CONTROL

FTX80295

Figure 27-85

flexible and are attached directly to the wing structure without hinges. The lower slot doors are attached by piano-type hinges to the wing leading edge lower structure.

(b) The inboard slot is located inboard of the inboard engine pylon. The inboard slot doors are connected by pushrods to an overcenter linkage. The overcenter linkage is connected by a drive crank to the inboard slot actuating cylinder piston rod end.

(c) The outboard slot, located inboard of the outboard engine pylon, is larger than the inboard slot. The outboard slot upper door is in three sections. The outboard slot doors are connected by pushrods to an overcenter linkage and torque tube. The torque tube is connected by a drive crank to the outboard slot actuating cylinder piston rod end.

(2) Wing Slot Control Valve

(a) The wing slot control valve controls the supply of hydraulic pressure to the slot actuating cylinders. The control valve is mounted on the right hydraulic manifold in the right wheel well.

(b) The control valve consists of a housing, slide valve, and an operating lever. The operating lever is connected by pushrod to one of the flap follow-up cable sectors in the right wheel well. Pressure outlets on the control valve are connected by hydraulic lines to the slot actuating cylinders. The pressure and return ports of the control valve are connected through the manifold to the main hydraulic power system.

(3) Wing Slot Actuating Cylinders

(a) The wing slot actuating cylinders drive the mechanical linkage that opens and closes the wing slot doors. The actuating cylinders are mounted in the wing leading edge section aft of each wing slot. Each actuating cylinder consists of a cylinder and a piston. The ports of the cylinder are connected by hydraulic lines to the wing slot control valve.

(b) Each inboard slot actuating cylinder is mounted in a vertical position with the lower end of the cylinder attached to the wing structure. The piston rod end is connected to the door mechanical linkage so that, when the piston is extended, the slot doors are closed.

(c) Each outboard slot actuating cylinder is mounted in a horizontal position with the aft end of the cylinder attached to the wing structure. The piston rod end is connected to the door mechanical linkage so that, when the piston is retracted, the slot doors are closed.

C. Operation

(1) The wing slot system is controlled by the flap follow-up cable system. When the flap control lever is moved to the extend position, the flaps extend and drive the flap follow-up cable system. The flap follow-up cable sector moves a pushrod which positions the slot control valve operating crank. When the flaps reach approximately 7 1/2 degrees of extension, the slot control valve slide is in the slots open position. The control valve directs hydraulic pressure to the slots open side of the slot actuating cylinder pistons. The pistons drive the slot door mechanical linkage to open the slot doors. The doors complete the aft surface of the curved slot, creating a venturi-like air passage aft of the wing leading edge vane and changing the lift characteristics of the wing.

(2) When the flaps are retracted, the flap follow-up sector, through the mechanical linkage, moves the slot control valve towards the slots closed position. When the flaps are approximately at the 2-1/2 degree position, the control valve slide is positioned to direct hydraulic pressure to the slots closed side of slot actuating cylinder pistons. The pistons drive the mechanical linkage to close the slot doors and complete the wing contour from the wing leading edge vane to the wing upper and lower surfaces.

(3) Each wing slot door mechanical linkage actuates a slot position switch which is a part of the wing slot - flap disagreement indicating circuit.

27. Stall Warning System - Description and Operation

A. General (See Figures 27-86 & 27-87)

(1) The stall warning system induces vibrations into the control columns if the airplane approaches a stall condition during flight. This provides a positive stall warning which cannot be overlooked or confused with other warning systems in the flight compartment. The system consists of a lift transducer, lift computer, control column shaker, test relay, and test switch.

(2) The lift transducer, located in the right wing leading edge, is the sensing mechanism for the stall warning system. The transducer consists of a heated vane and mounting plate, armature and pivot, E-core transformer, and a housing.

(3) The lift transducer heater is turned on whenever the ANTI-ICING & METER SEL switch, on the overhead switch panel, is in any position except OFF. The heater may be checked for proper operation by placing the selector switch in the STALL WARN position and noting the indication on the adjacent anti-icing (PITOT AMP) ammeter. The HEATER INOP light monitors several anti-icing heaters through a current sensing detector mounted on the EPC equipment panel. If the stall warning heater current drops below 1.2 amps, or rises above 2.8 amps, a relay contact within the detector will close causing the monitor light to come on. The relay will open, causing the light to go off, when heater current returns to either 5 percent above the low limit, or 5 percent below the high limit. The HEATER INOP light will also come on whenever the meter selector switch is in the OFF position.

(4) The lift computer, located in the accessory compartment, is the signal summing and relay unit for the stall warning system. The computer consists of an ac to polar dc signal converter and a transistor operated relay.

(5) The mode transfer relay is actuated by a flap limit switch to provide warning when the airplane approaches a stall condition with the flaps in the up position, in addition to the existing flaps down stall condition warning.

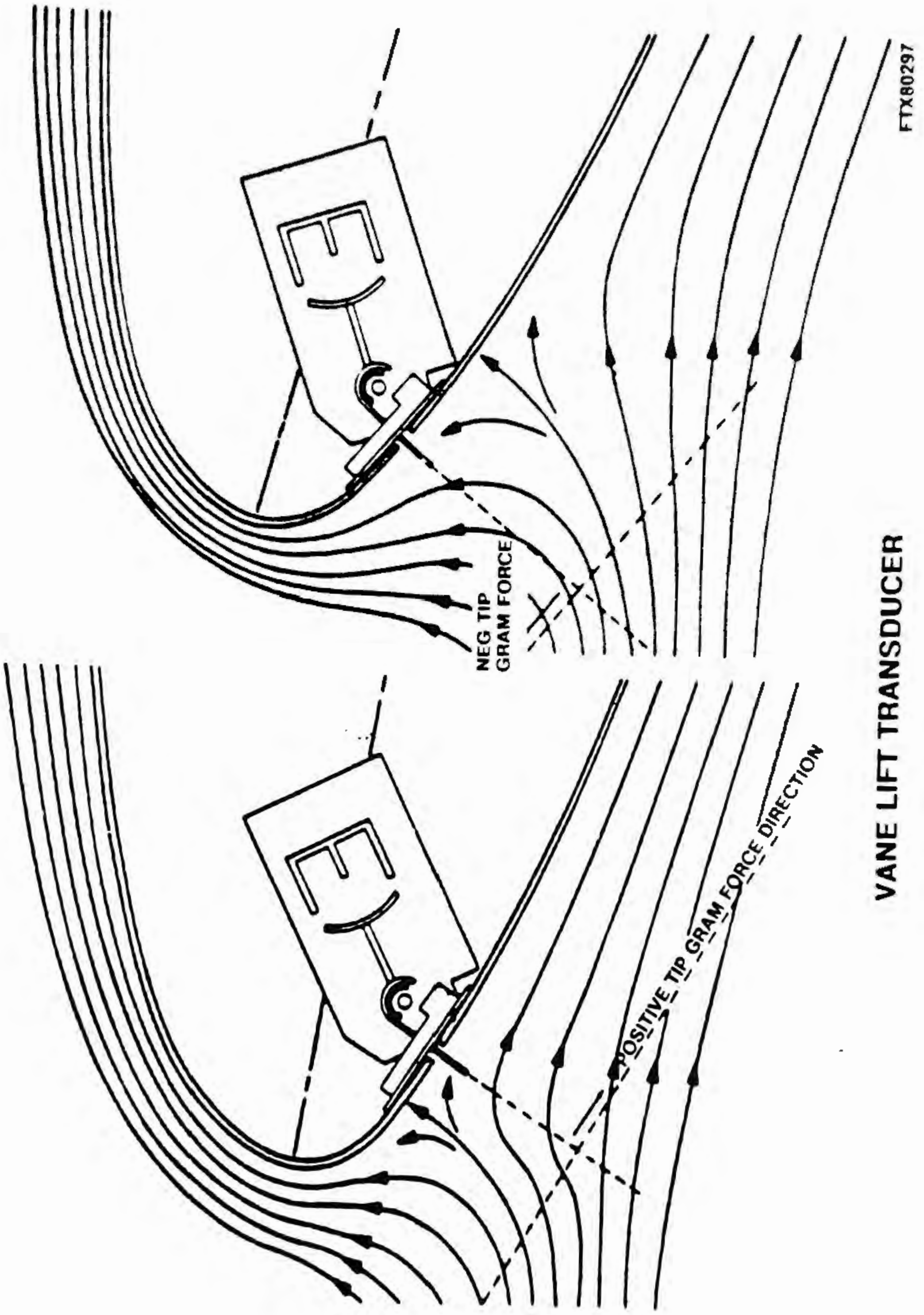
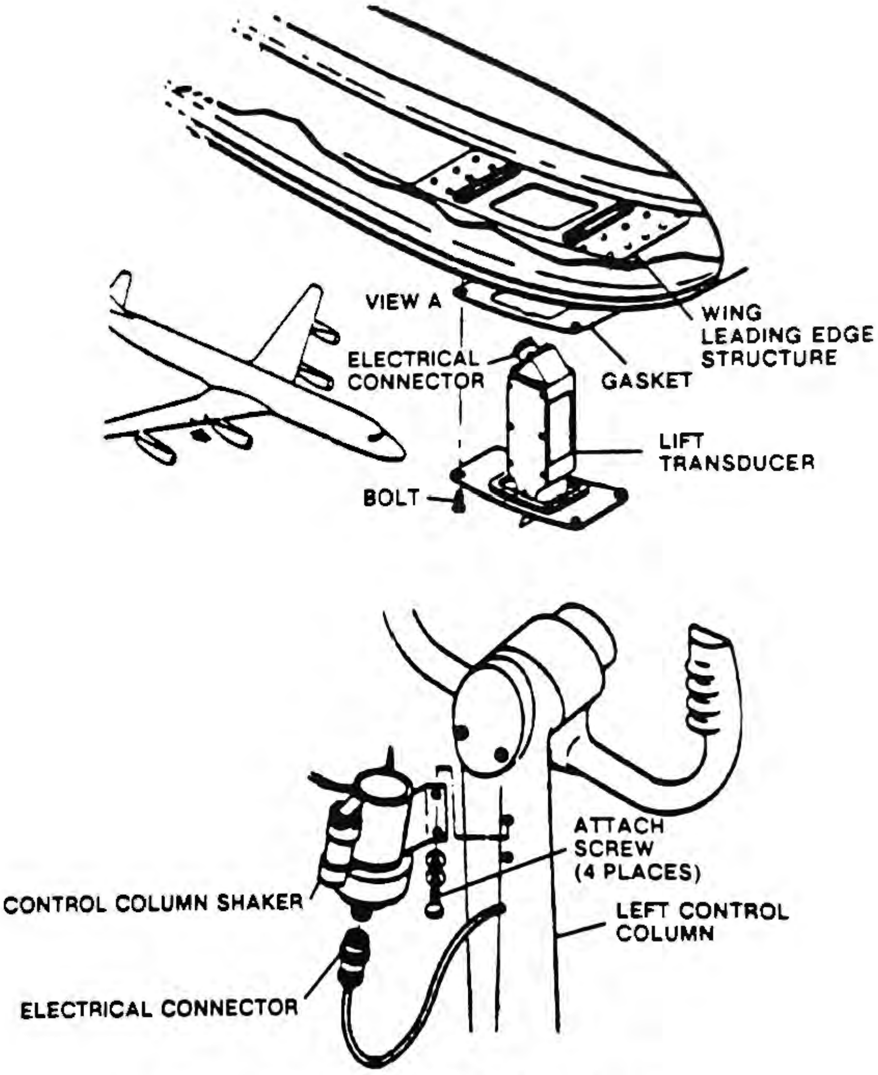

FTX80297
NEG TIP GRAM FORCE
POSITIVE TIP GRAM FORCE DIRECTION
VANE LIFT TRANSDUCER

Figure 27-86



STALL SYSTEM COMPONENTS FTX80298

Figure 27-87

(6) The control column shaker, located on the forward side of the control column, induces vibrations into the control column on receipt of a signal from the lift computer. The shaker consists of a 28-vdc motor, an eccentric mass, striker cylinder, and a radio noise filter. The eccentric mass is attached to the striker cylinder by a pivot so that the mass rotates around the cylinder. The motor is attached to a casing at the lower end of the eccentric mass and is connected by a pinion gear to a gear within the mass. The radio noise filter is installed inside the striker cylinder.

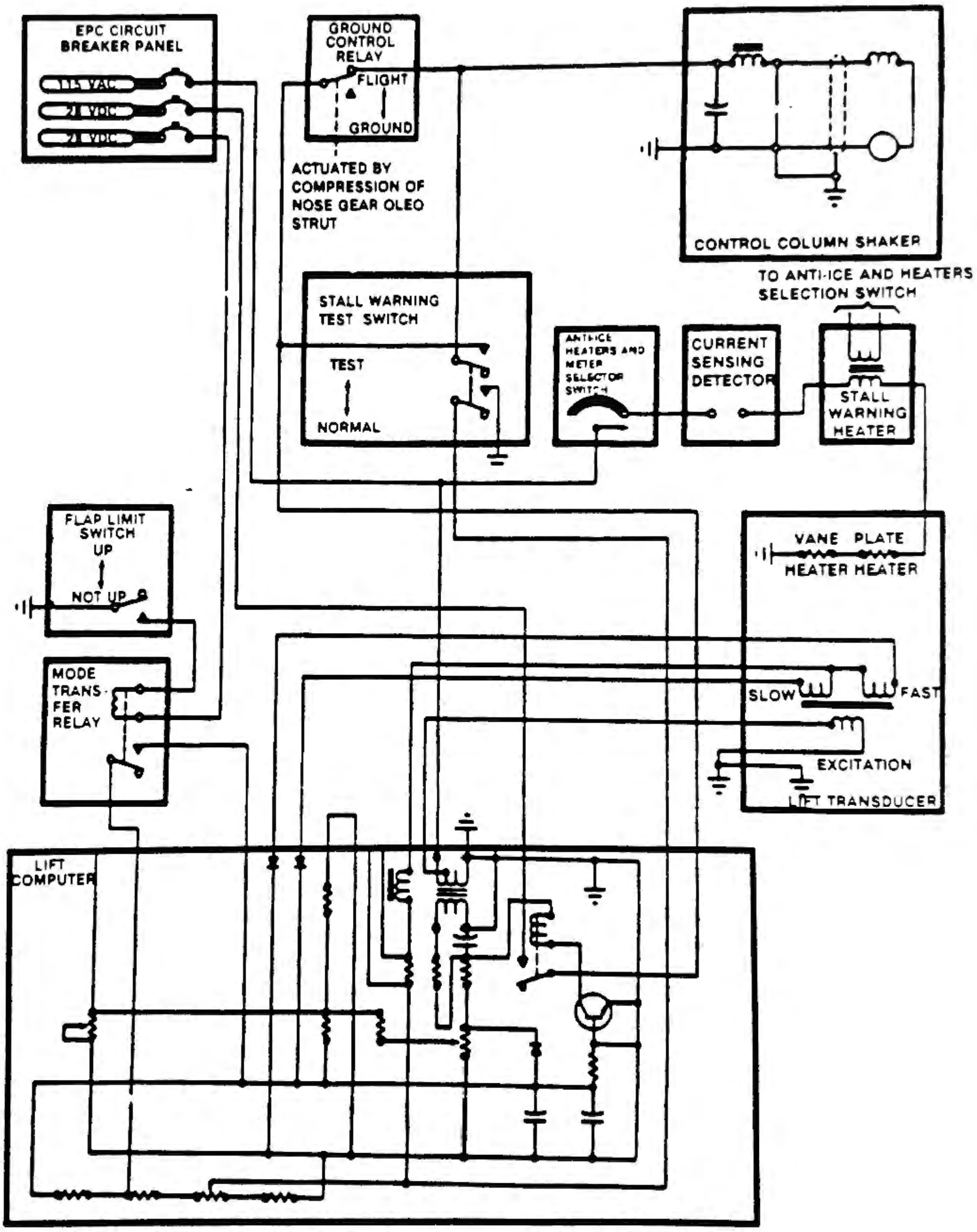
(7) The test switch, located on the overhead switch panel, in the flight compartment, is used to test the operation of the computer and the control column shaker.

B. Operation (See Figures 27-88 & 27-89)

(1) The vane of the lift transducer, attached to the armature pivot, protrudes through the wing leading edge lower surface so that when the airplane is in flight, aerodynamic forces on the vane move the armature. The center leg of the transducer transformer core carries an excitation coil. Fast and slow coils are located on the outside legs of the core. Position of the armature in relation to the coils determines the values of the output signals which are transmitted to the lift computer.

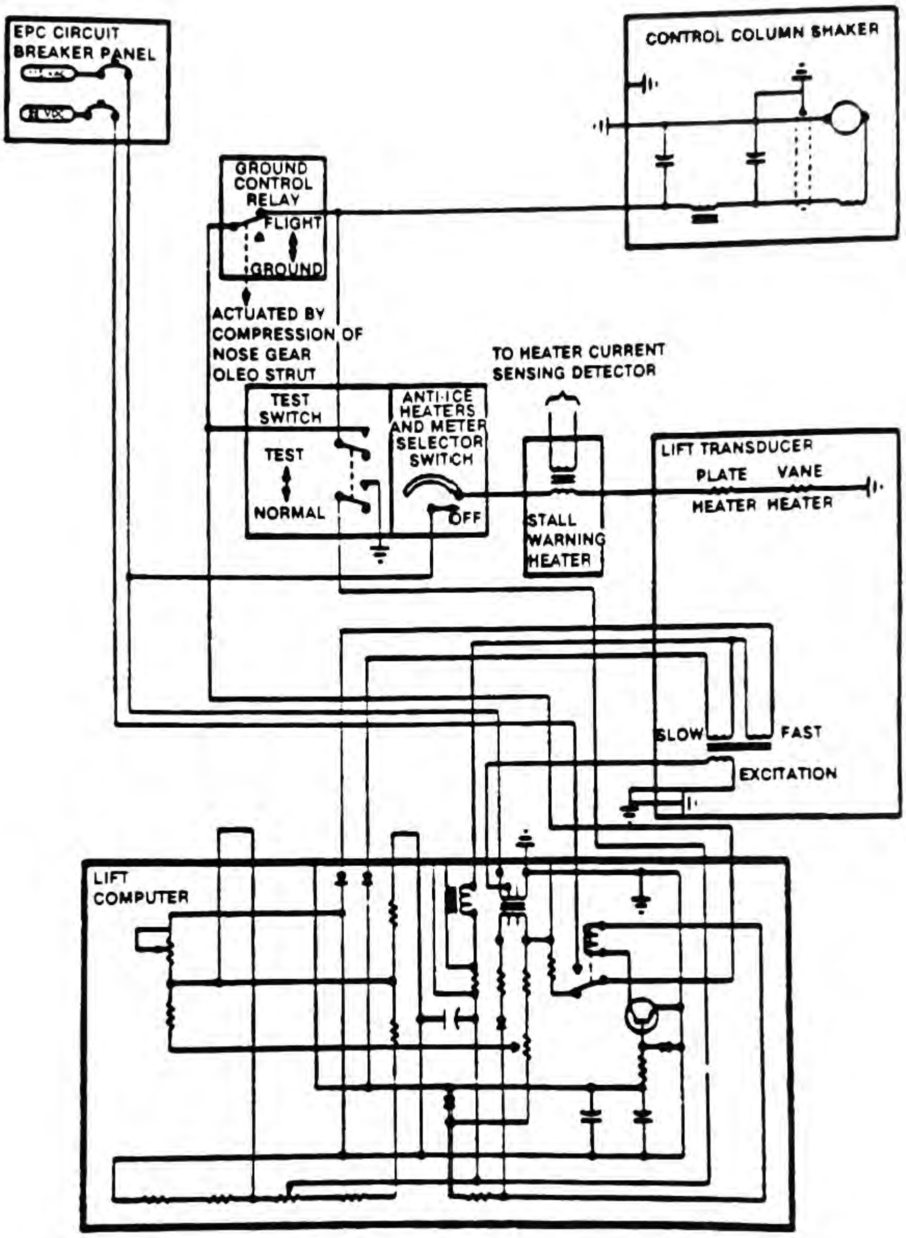
(2) In the computer, the signal converter, along with the fast and slow coils in the lift transducer, forms a bridge circuit which converts the transducer ac signals to a single polar dc signal. This converted signal is proportional to the difference between the two ac signals received from the transducer. The dc output of the bridge is applied to the base of a transistor and when the signal attains a specific polarity and amplitude, the transistor is operated to act as a switch to apply current to a relay coil. The normally open contacts of the relay close, completing a 28-vdc circuit (through the contacts of a ground control relay) to the control column shaker.

(3) The mode transfer relay and flap limit switch change the characteristics of the bridge circuit by switching in an additional resistor in the computer when the flaps are at zero (flaps up) condition. This in-



STALL WARNING SYSTEM -- SIMPLIFIED SCHEMATIC FTX80296

Figure 27-88



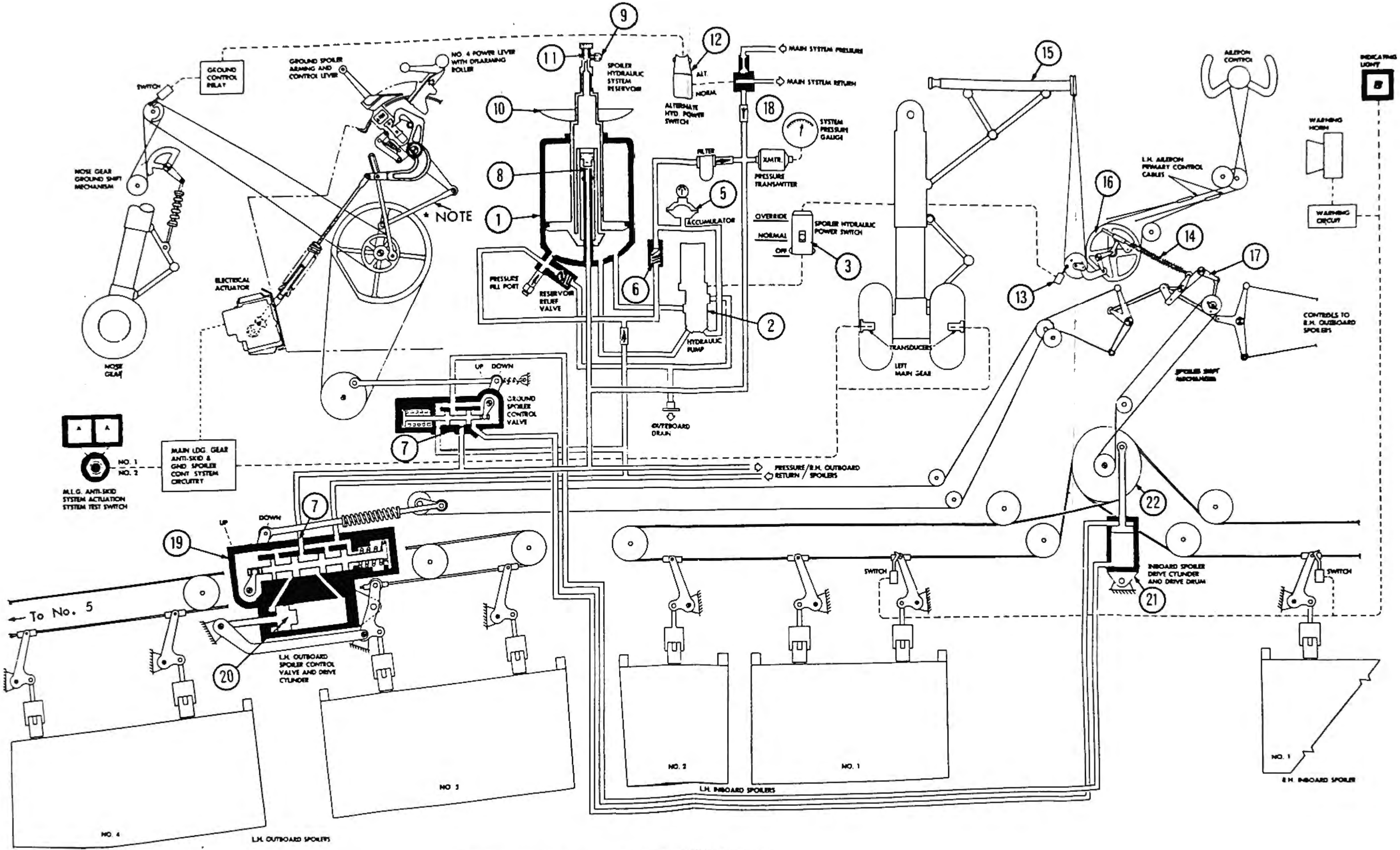
STALL WARNING SYSTEM (61 SERIES) FTX80299

Figure 27-89

creases the tip gram force necessary to actuate the lift transducer vane in a positive (aft) direction. When the flaps are down, the resistor is out of the circuit and the mode transfer relay is energized.

(4) On receipt of a signal from the lift computer, the motor and the annulus which houses the eccentric mass are driven to strike opposite sides of the striker cylinder alternately. Two such strikes are made with each rotation of the eccentric mass. This imparts a combination of shakes and knocks to the left control column. Sufficient transmission is obtained through the mechanical linkage between the two control columns for the warning to be felt and heard in both columns. Since the signal from the computer is routed through the contacts of a ground control relay, the control column shaker is disengaged when the airplane is on the ground and the nose gear oleo strut is compressed.

(5) The test switch is connected to the coil of a test relay. Normally open contacts of the relay are included in the computer test circuit to the control column shaker. When the test switch is operated, the relay contacts are closed and the computer bridge circuit is unbalanced to simulate a stall signal. This signal is applied to the control column shaker through the test relay contacts, thus bypassing the ground control relay.



NOTE - SPOILER LEVER LOCKOUT NOT SHOWN

SPOILER SYSTEM

1. General - Description and Operation

A. Description (See foldout in the back of this Manual)

(1) The airplane fuel system is divided into storage, distribution, dump, and indicating. Storage includes tanks and sealing, vent system, and reservoir feed systems. Distribution includes the tank fill system and the engine fuel supply system up to the engine nacelles. The dump is concerned with dumping fuel overboard. The indicating system includes fuel quantity indicating, reservoir feed pump pressure indicating, low-level warning, and fuel temperature indicating system.

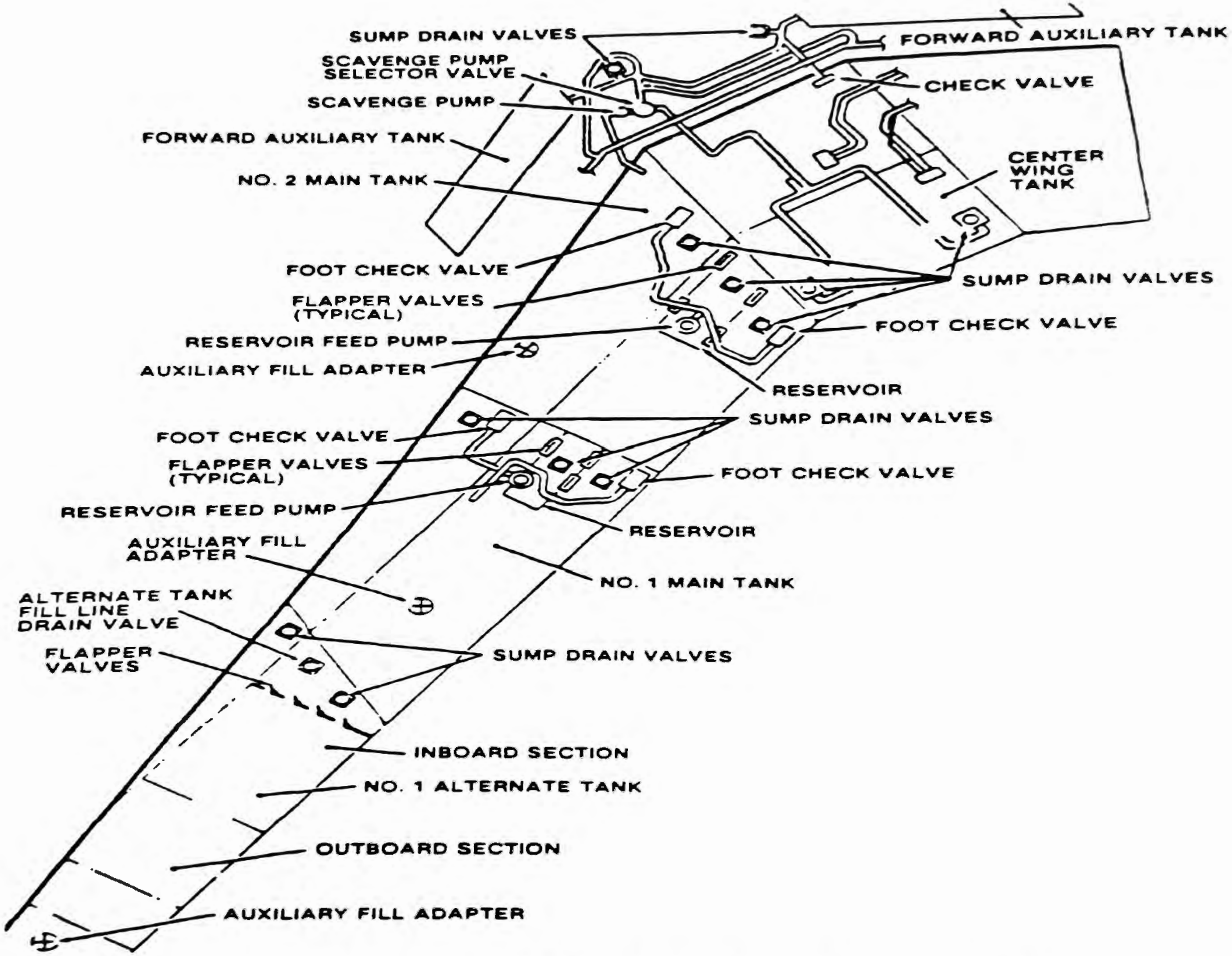
(2) The fuel system contains eight integral tanks. The No. 1 and No. 4 main and alternate tanks are paired, two to each outboard engine. There are two main inboard tanks numbered to correspond to the inboard engines. The seventh tank is in the center wing. The eighth tank consists of the left and right leading edge tanks which are joined together by a crossover line. The tanks can be filled individually or simultaneously through the pressure refueling adapters connected to the crossfeed manifold. The main tanks can also be gravity fueled through the auxiliary fill adapters in the upper wing surface. The engine fuel supply system utilizes the same crossfeed system as the tank fill system to accomplish crossfeeding and fuel transfer.

(3) The controls and indicators for the fuel system are located in the flight compartment.

2. Storage - Description and Operation

A. General (See Figure 28-1)

(1) The fuel storage system consists of the fuel tanks and components, and the vent system. The tanks are integral with the wing. Flapper valves are located in closing bulkheads in the inboard end of each main tank and alternate tank to form a reservoir. Sump drain valves are provided in the lower portion of all tanks and the alternate tank fill line to permit draining of residual fuel. Auxiliary fuel servicing is accomplished by means of overwing fuel tank fill adapters, one in each main and alternate tank upper wing skin.



FUEL TANKS AND COMPONENTS - SCHEMATIC

FTX80714

Figure 28-1

(2) A vent system is provided to prevent overboard fuel spillage during ground or flight maneuvers. The system also prevents tank overpressure during filling and maintains pressure differential between the tank and ambient pressure, within allowable limits, for all airplane flight conditions. A combination vent and fill line is installed between the outboard section of the alternate tank and the alternate tank reservoir. A fuel recirculating line and a check valve are installed between the end of the fill and transfer line and the boost pump.

(3) A means is provided to permit utilization of the residual fuel in the center wing tank and the crossfeed line. Fuel from the scavenge line or crossfeed line is drawn through a selector valve and pumped into the No. 2 main tank for further transfer to the distribution system. An electric heating blanket is cemented to the underside of the sump channels to melt any ice that may have formed in the sump and blocked the scavenge pump pickups.

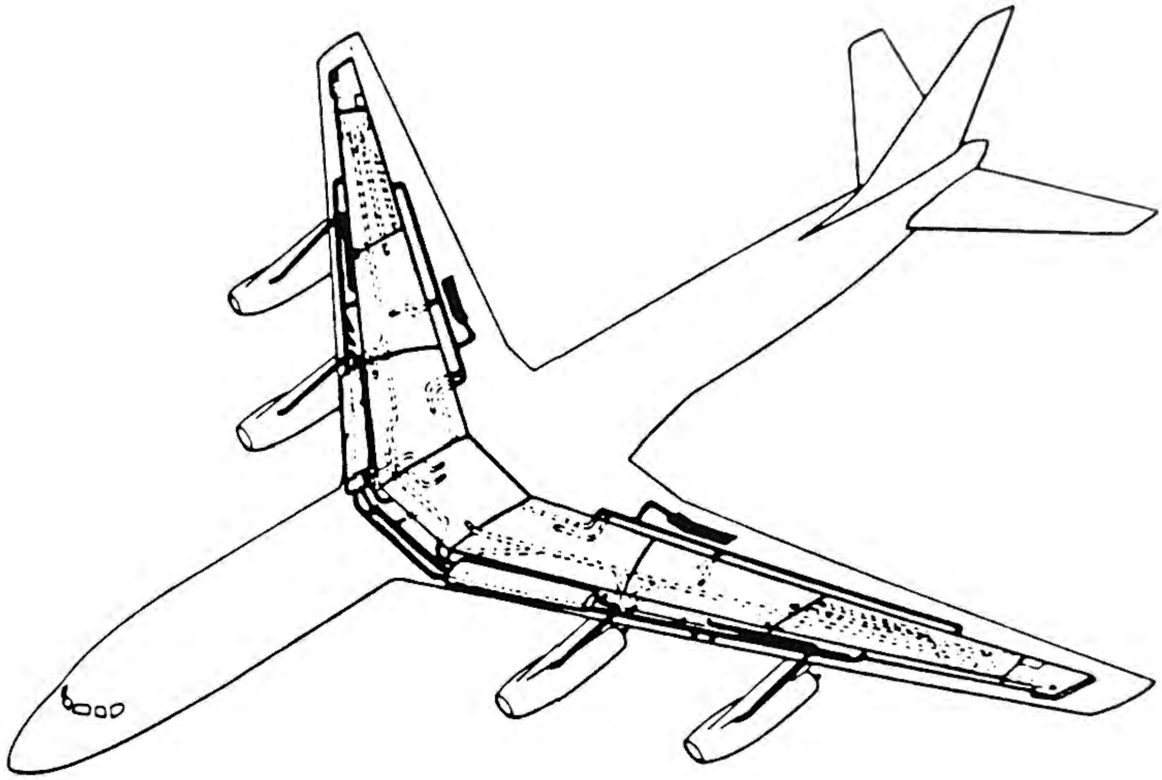
3. Description Fuel Tanks and Components

A. Fuel Tanks (See Figure 28-2)

(1) Eight integral wing fuel tanks provide storage for fuel. There are four main tanks, two alternate tanks, one center wing tank and two interconnected leading edge tanks (the tenth tank) with the alternate tanks outboard of their respective main tanks. The front and rear walls of the main and alternate tanks are formed by the front and rear wing spars. Fueltight bulkheads from the inner and outer walls of these tanks with upper and lower wing panels forming the top and bottom of the tanks. The alternate tanks are divided into an outboard and an inboard section by a closed bulkhead.

(2) The wing tanks are numbered from left to right respectively: No. 1 alternate, No. 1 main, No. 2 main, No. 3 main, No. 4 main, and No. 4 alternate.

(3) Each main tank and the inboarded section of the alternate tank have an integral reservoir in the inboard end that retains fuel to keep the fuel boost pump submerged at all normal flight attitudes. The main tank reservoir is immediately aft of the center spar between the wing upper and lower panels. The forward and aft walls of the reservoir are stepped to reduce the amount of unusable fuel at extreme flight attitudes. Reservoirs are formed by closing bulkheads with flapper



FUEL TANKS ARRANGEMENT - DC-8 62/63

FTX80715

Figure 28-2

valves. These valves permit fuel to flow inboard but prevent fuel from flowing outboard away from the boost pumps in a wing-low attitude or other similar situation. The retained fuel provides a head of fuel to keep the boost pumps submerged at all normal flight attitudes and during all normal maneuvers.

(4) The primary means of tank internal sealing is a close-tolerance metal-to-metal fit. Sealant is used for bead seals, dams, and faying seals. Corrosion protection is provided by a polyurethane covering on the bottom and lower 4 inches of the tank sidewalls.

(5) The top surface of the center wing constant section and forward face of the center wing front spar which forms a part of the center wing fuel tank are sealed with a fuel vapor barrier coating material. The coating is applied to these external areas of the tank by brushing and/or spraying. The vapor barrier coating acts as an additional sealant to prevent fuel vapors from escaping the tank and entering the pressurized areas of the fuselage.

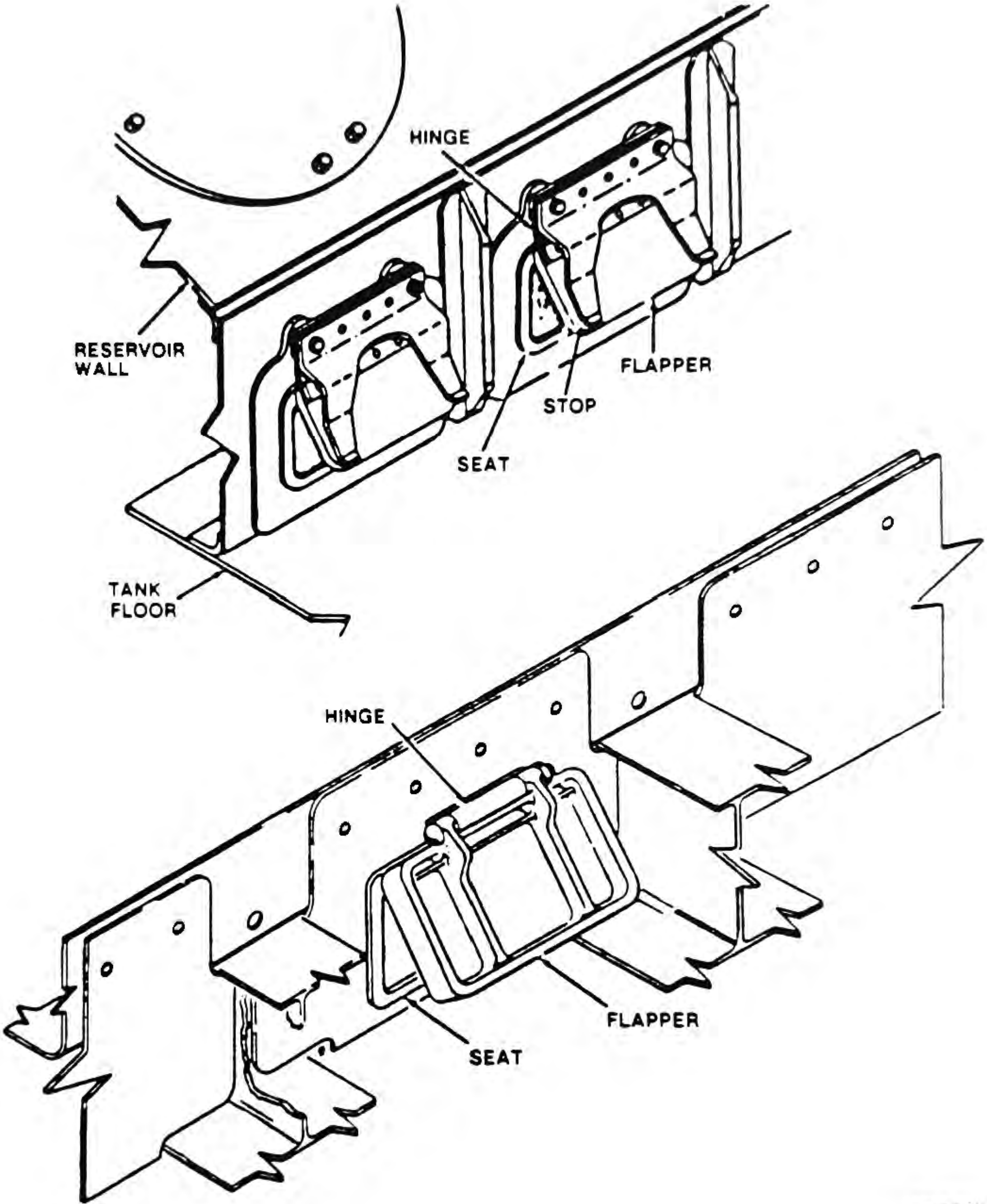
(6) To insure complete sealing of the tank top surface, a mylar patch is cemented over fuel tank access doors and fuel quantity probe access covers.

B. Reservoir Flapper Valves (See Figure 28-3)

The flapper valve assembly consists of a flapper, fairprene hinge, and a main tank stop. The stop is attached to the top of the hinge and limits the open travel of the hinge. The valve is attached to the reservoir wall and allows fuel flow into the reservoir. The valve prevents fuel from flowing from the reservoir into the tank. The alternate tank flappers consist of a hinged flapper attached to a plate.

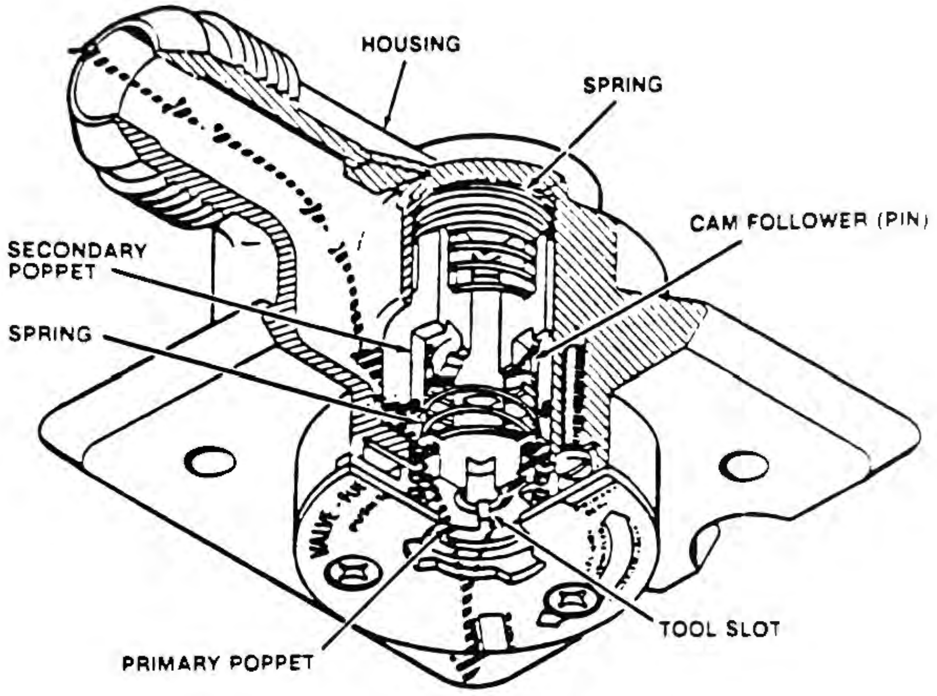
C. Tank Sump Drain Valves (See Figure 28-4)

(1) The tank sump drain valves are the tool-operated, dual-poppet type and are internally mounted in the lower wing skin. The valves are located in the lower inboard portion of the tanks to allow the draining of sediment, moisture, and/or residual fuel from the tanks and the alternate tank fill line. Pickup pipes are connected to the drain valves. The pipe inlets are above the bottom of the tank.



RESERVOIR FLAPPER VALVES - SCHEMATIC

Figure 28-3



TANK SUMP DRAIN VALVE - SCHEMATIC

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Figure 28-4

(2) The primary poppet may be externally removed, and replaced, from under the wing without draining the tank. The secondary poppet may also be removed externally, but the tank must be drained to do so. The valve housing is removed from within the tank after defueling.

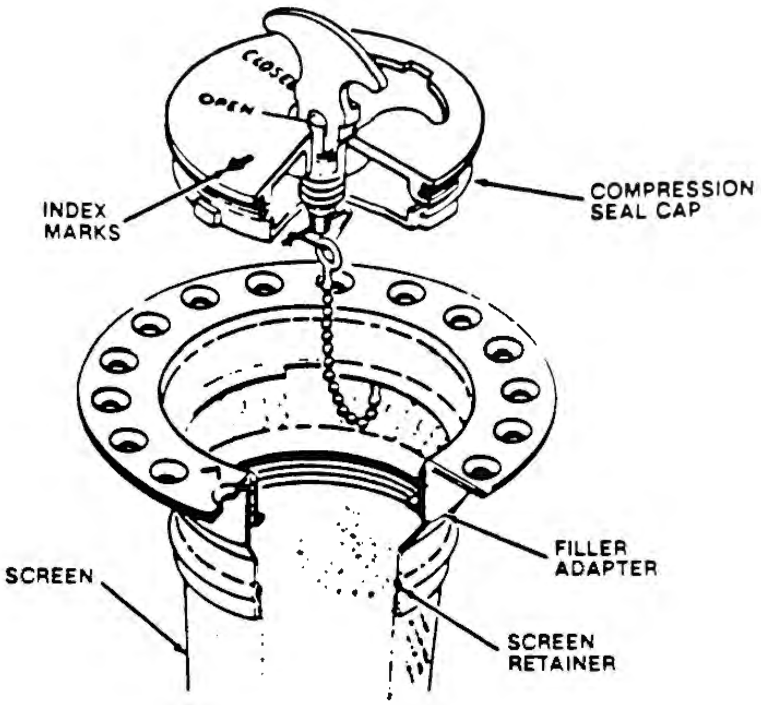
(3) The primary poppet is housed in, and positioned by, the secondary poppet. A spring inside the secondary poppet normally holds the primary poppet on the seat. A pin pressed through a drilled hole in the primary poppet stem acts as a cam follower and rides against the cam portion of the secondary poppet. The face of the primary poppet is slotted so that a screwdriver or special tool may be used to operate the valve. The poppets are retained in the housing by individual seats. The center portion of the valve cover is open and has three equally spaced notches that allow for tool operation of the valve.

(4) Normally, the tool slot in the primary poppet is aligned with the normal position on the cover plate. In this position, both poppets will be seated. Rotating the primary poppet counterclockwise 129 degrees to the check primary seal position forces the secondary poppet up and exposes the primary seal. To drain the sump, the primary poppet should be depressed. This will force the secondary poppet off the seat and allow tank sediment to drain overboard. After removing the drain tool, the return springs will reseat the poppets and the drainage will cease.

D. Auxiliary Fill Adapters (See Figure 28-5)

(1) Auxiliary fill adapters are provided for overwing servicing of the fuel systems in the event the underwing pressure refueling equipment is not available. The auxiliary fill adapter assembly consists of a pressure-sealed cap, tank adapter, and filler screen. Each wing tank has an auxiliary fill adapter. The outboard alternate fill adapters of the No. 1 and 4 tanks are integral with the wing upper panels. Fill adapters for the remaining tanks are located in removable wing access doors. The adapters are flush mounted.

(2) The flanged filler neck has a groove near the bottom end for securing the screen assembly. The No. 1 and 4 main and alternate tanks have holes around the neck to enable more complete overwing fueling of these tanks.



AUXILIARY FILL ADAPTER - SCHEMATIC

FTX80718

Figure 28-5

(3) All filler caps are the same and consist of a handle, base, cone, spring, and shaft. The cap has a recess for the handle and has CLOSED and OPEN placarded positions. The cap has an arrow for cap indexing to adapter face. A large O-ring is located in a groove around the outer periphery of the base.

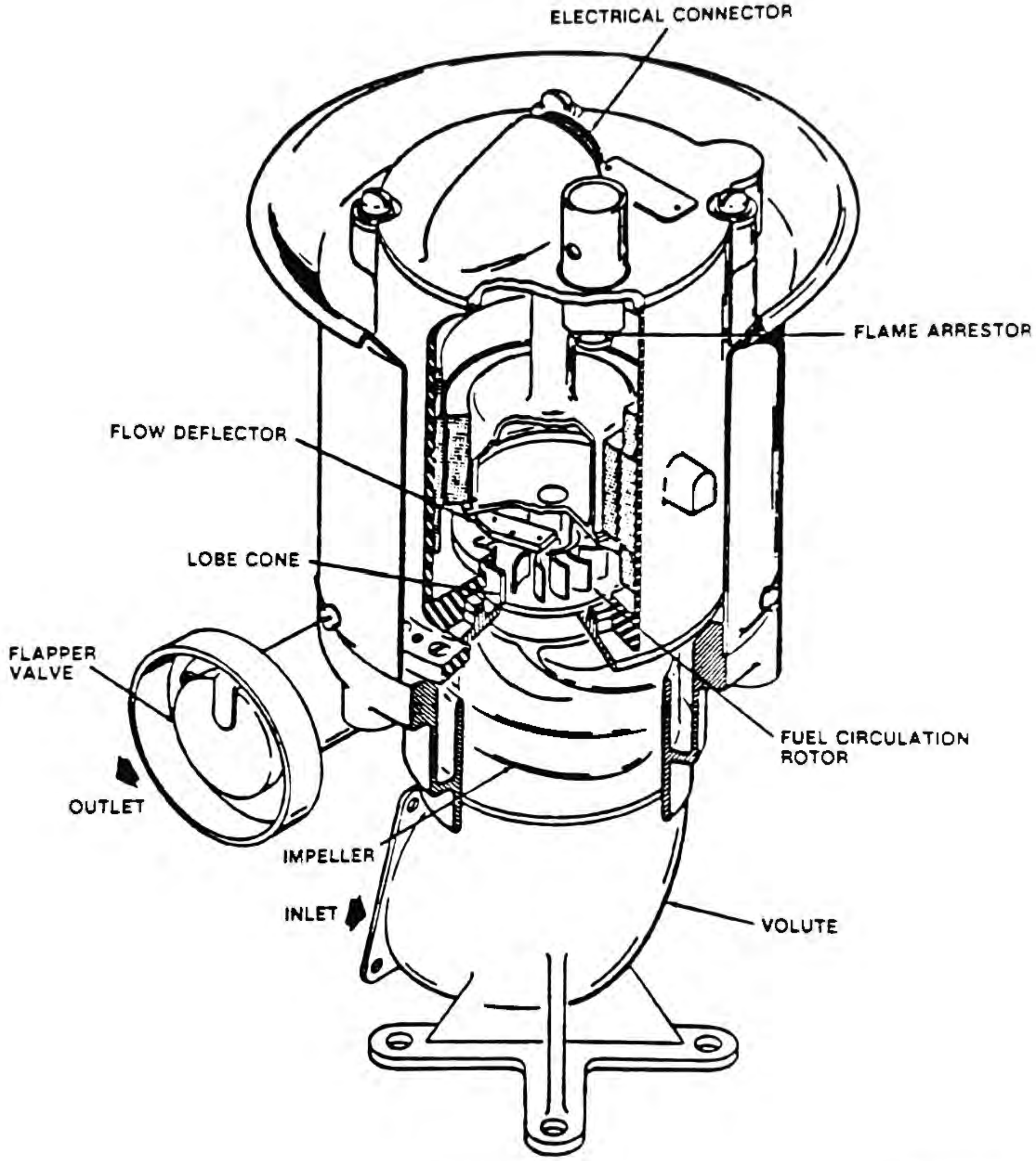
(4) To remove the cap from the adapter, the handle of the cap must be lifted. This allows the spring to force the cone slightly downward so the dogs on the cone do not come in tight contact with the indexing lip of the adapter. This relieves the force at which the cap is held seated to the adapter and allows the handle to be turned counterclockwise from the closed position to the open position. This rotates the cone to a point where the dogs will be aligned with the slots in the indexing adapter, and the cap may then be lifted from the adapter. A retaining chain prevents the cap from being lost. To install the cap, the procedure may be reversed.

E. Reservoir Feed Pumps (See Figure 28-6)

(1) There are four reservoir feed pumps located, one each, in the main tank reservoir. Each pump locks into a volute, which is attached to the tank structure. The pump consists basically of a 3-phase, AC, submersion-type motor and an impeller to pressurize the fuel. Each pump is controlled through one position of the same switch that controls the corresponding fuel boost pump.

(2) The pump may be removed from the volute by using a special tool, if the fuel level is below the access door. All pumps are reached through access doors, directly above the pumps, in the top of the wing.

(3) The pump has two lugs halfway down the housing for use with the removal and installation tool. Two additional lugs at the bottom of the housing are provided to secure the pump inside the volute. The impeller is enclosed in a cover that screws into the bottom of the motor housing. The upper portion of the cover is slotted to allow fuel to flow out the impeller and into the volute. The pump is the same in all tanks and consists basically of an armature shaft, motor field windings, lobe cone, fuel circulation rotor, impeller, and temperature limit switch. The temperature limit switch in the motor housing opens the electrical power circuit to the motor if the motor overheats. If the motor overheats, it must be replaced. Fuel is circulated through the motor for cooling purposes.



RESERVOIR FEED PUMPS - SCHEMATIC

Figure 28-6

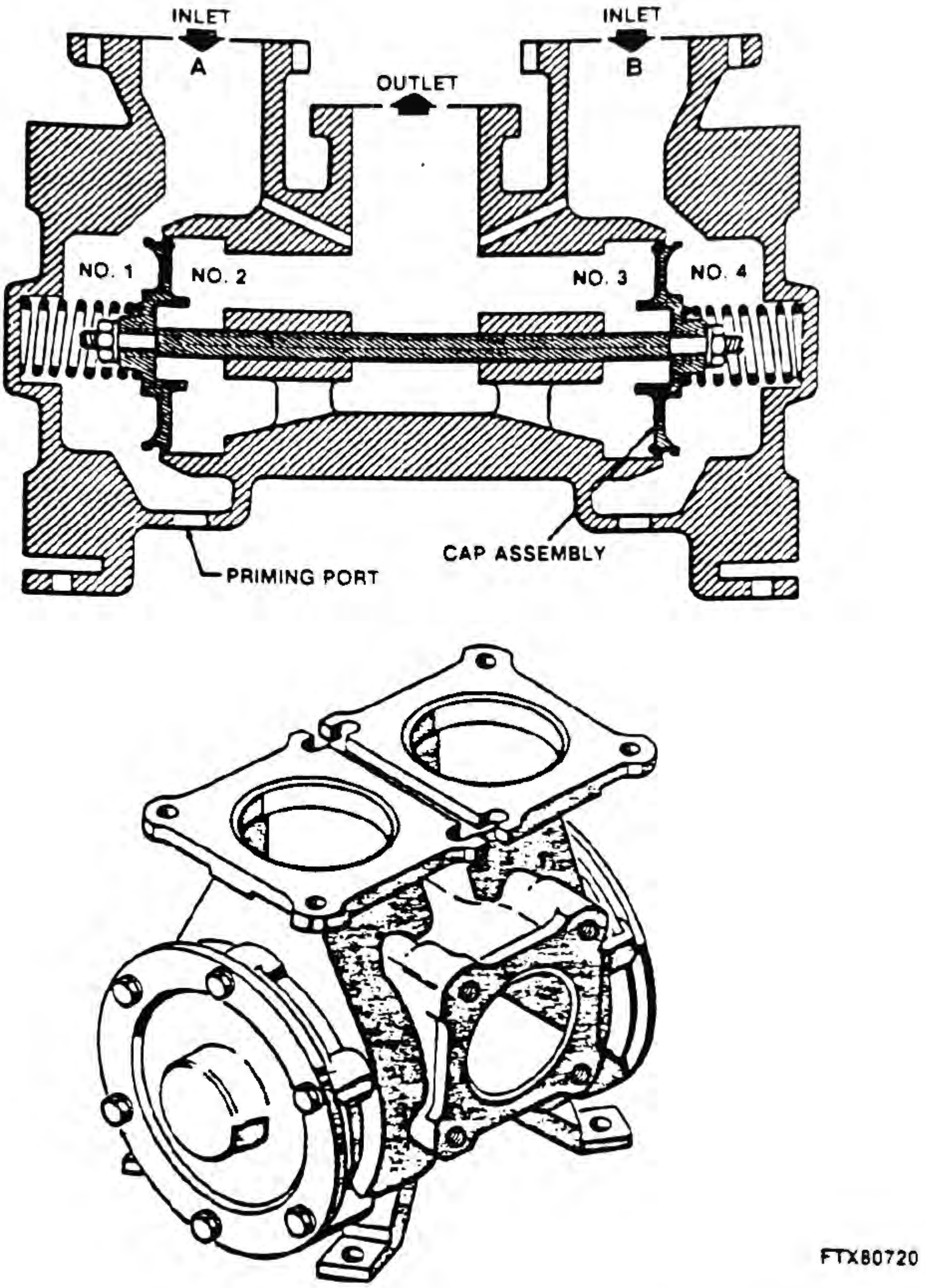
(4) The volute consists of a guide and a housing assembly with two locking pins and a spring-loaded flapper valve. The volute guide receives and mounts the pump assembly. The locking lugs on the motor housing are turned against the stops in the volute housing until the locking pins snap into locking position. In this manner the locking lugs are held under the volute housing flange. The inlet port in the reservoir feed pump volute receives fuel from the self-selecting valve. The outlet port empties directly into the reservoir. A flapper check valve is installed in the outlet port.

F. Reservoir Feed Pump Inlet Selecting Valve (See Figure 28-7)

(1) The reservoir feed pump inlet selecting valves are located in the main tank reservoirs. Each valve is a double entry, single outlet, shuttle-type valve. The valve, located in the suction side of the reservoir feed pump, will automatically select one of two fuel supply pickup lines of the reservoir. The pickups are in the fore and aft portions of the tank; and, depending on tank fuel quantity and airplane attitude, one pickup may become exposed to air while the other remains submerged. Thus, the valve ensures continuous fuel supply into the reservoir.

(2) The top portion of the valve housing has two flanged inlet ports to which the fuel pickup lines of the reservoir are mounted (fore and aft). A flange adapter for the valve outlet port is positioned on one side and is connected to the suction side of the feed pump. Two priming ports in the bottom side of the housing allow reservoir fuel to enter the valve chamber, maintaining valve prime. Internally, the housing is divided into two equal chambers, 1 and 2 and 3 and 4. Each chamber has an independent inlet, priming port, and air vent orifice. A shaft extends between these chambers with identical cap assemblies on each end (A and B). Two working springs, one at each end of the shuttle valve, position and aid in the shifting of the valve. An outlet port is centered between the valve chambers and has the two air vent orifices that extend into the inlet chambers (A and B).

(3) The cap assemblies are bolted to the shaft ends, and each has a bonded seal on the inside seating face. The outer periphery of the cap has a small groove that functionally aids in positioning the shuttle valve by increasing its selective sensitivity to pressure differential changes across the cap with the shuttle neutrally positioned.



RESERVOIR FEED PUMP INLET SELECTING VALVE - SCHEMATIC

Figure 28-7

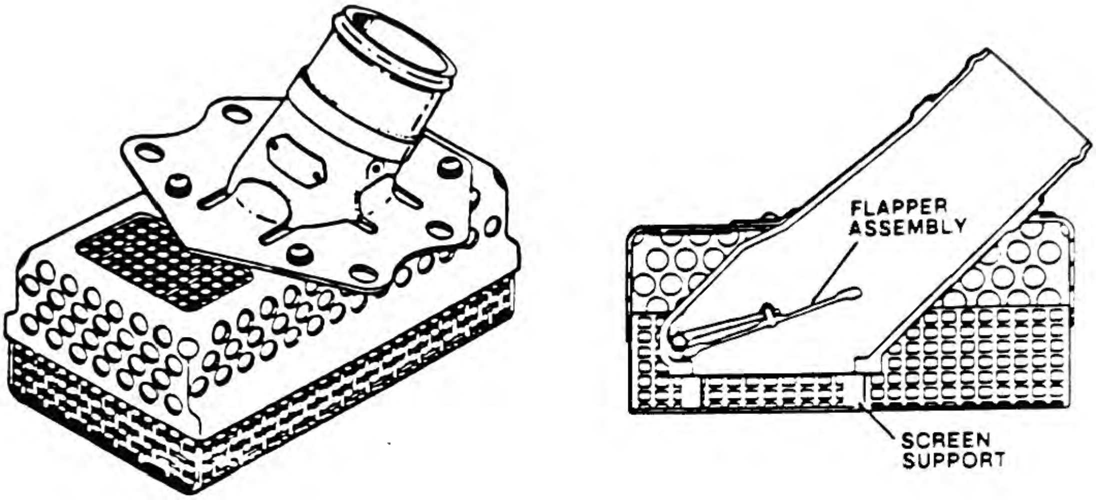
(4) Fuel enters the two priming holes, fills valve chambers 1 and 4, and flows into inlet chambers A and B. When the reservoir feed pump is activated, it draws slug-type fuel flow (air and fuel) from the valve outlet port. The lower pressure created in the outlet by the pumping action causes flow around each cap (A and B) through the established clearance between the cap outer periphery and the housing. This flow would be from chamber 1 to 2 and from chamber 4 to 3. The small groove in the cap outer periphery disturbs this flow, thereby increasing the pressure drop across the cap. The valve, unstable in this neutral position, starts to hunt and moves to select either of the two legs attached to inlet A or B.

(5) The hunting of the shuttle valve, for example, moves cap B toward the No. 4 chamber area allowing differential pressure across the cap to equalize. Simultaneously, cap A moves in the housing toward he No. 2 chamber area because the No. 1 chamber has the higher pressure. This differential pressure drop across cap A is sufficient to overcome cap B's spring force and to continue moving the shuttle until cap A seats. In this position, the valve has fully opened inlet B to the suction side of the feed pump and will remain in this position until the pickup lines, attached to inlet B, become exposed to air. At this point, the pump starts drawing air in through inlet B, breaking the low pressure created in this portion of the valve due to the high flow rate demand of the pump. The compressed spring force cap B is now sufficient to offset cap A and return the valve to neutral. With the pump continuing to draw air through the valve inlet, flow is induced through both air vent orifices.

(6) With one pickup line vented; the pressure drop in inlet B and chambers 3 and 4 is slight. However, the pressure continues to decrease in the submerged line, inlet A, and the valve outlet. This is because the pump draws through the respective vent orifice and lifts the fuel over the high point in the line piping. The valve, again unstable and flow sensitive in the neutral position, starts to hunt. Cap A moving toward the No. 1 chamber area has the differential pressure across it equalized by moving out of the valve housing portion. Cap B is now positioned in the housing, and the No. 4 chamber pressure, which is higher than that of No. 3 chamber, moves the shuttle to fully open inlet A to the outlet and feed pump. Through this type action,

the self-selecting valve automatically determines which of the two pickup lines is required to maintain and ensure fuel supply to the reservoir box during normal system operation.

G. Foot Check Valves (See Figure 28-8)



FOOT CHECK VALVE - SCHEMATIC

Figure 28-8

(1) The foot check valves are flapper-type valves provided to prevent fuel from draining out the inlet end of the reservoir feed pump supply lines.

(2) Each valve consists of a flapper, a housing, and a screen assembly. The flapper housing extends out of the screen assembly at approximately a 45-degree angle. The screen is made of perforated sheet metal and standard wire mesh screen. The flapper valve is inside the screen. Four spacers prevent the screen from being forced into the flapper inlet. The flapper is hinge mounted inside the housing and has a spring to ensure proper seating. The flapper is a self-aligning type with approximately 45 degrees of travel from closed to full open.

(3) Suction of the feed pump pulls fuel through the inlet, opening the flapper. The flapper will remain open as long as the line is selected and the pump is operating.

H. Scavenge Pump (See Figure 28-9)

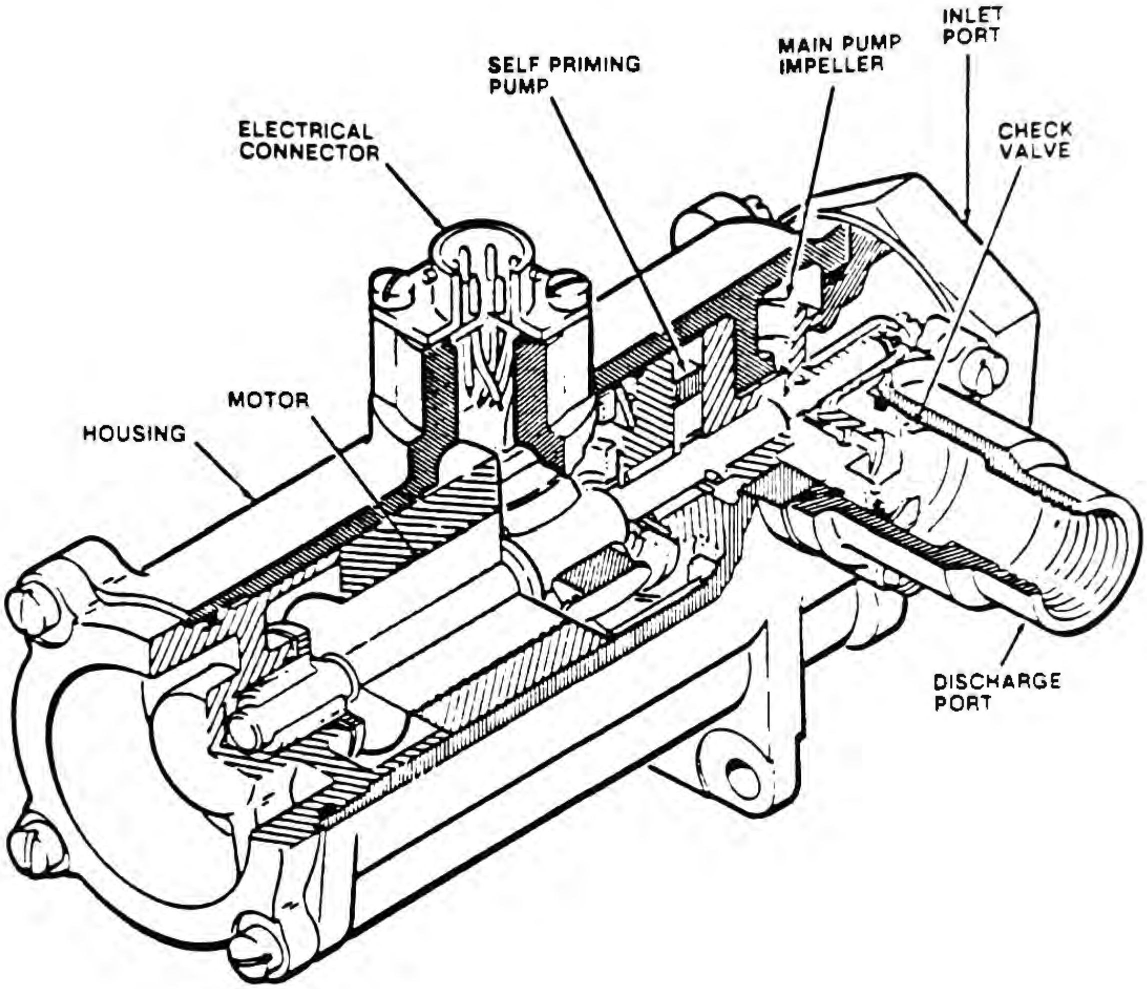
The scavenge pump is provided to scavenge fuel from the center tank sump and the crossfeed manifold. The pump is an AC motor-driven, self-priming pump. The pump is comprised basically of two pumps within a single housing. The vane-type, positive displacement pump provides the self-priming feature, while the main impeller type pump provides the high flow of fuel. The pump operates on three-phase, 400 cycle, 115/200 volt AC power supplied through circuit breakers on the fuel management and engine section of the EPC circuit breaker panel in the flight compartment.

I. Scavenge Pump Selector Valve (See Figure 28-10)

The scavenge pump selector valve is provided to select the source of scavenged fuel from either the center tank sump or the crossfeed manifold. The valve is a motor-driven, ball-type valve with two inlet and one outlet ports. A manual override arm is provided. The valve motor operates on 28 volt DC power supplied through a circuit breaker on the fuel management and engine section of the EPC circuit breaker panel in the flight compartment.

J. Fuel Recirculating Check Valve (See Figure 28-11)

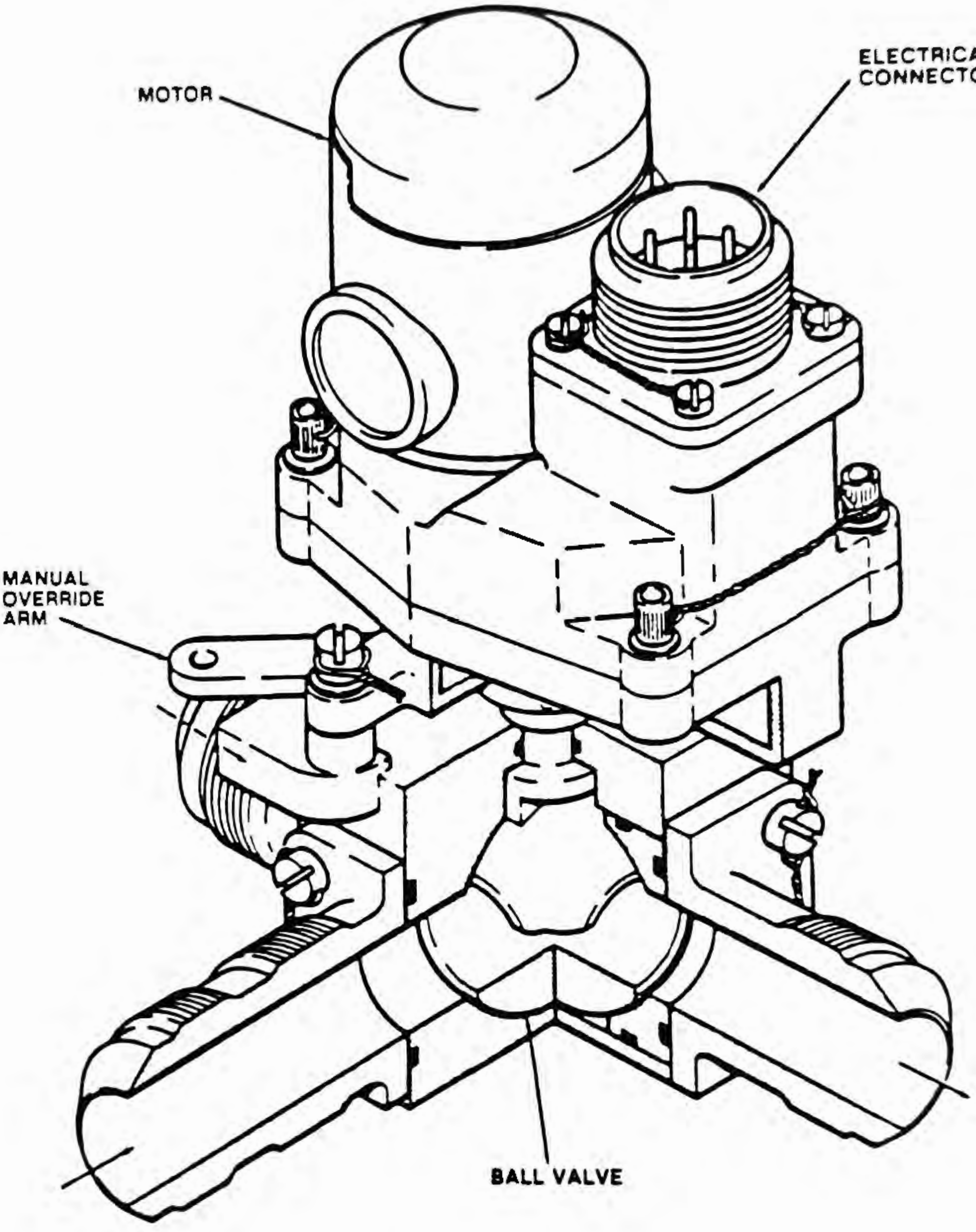
The fuel recirculating check valve permits fuel to flow from the boost pump into the inboard end of the outboard alternate fill line but prevents reverse flow during tank filling. The valve consists basically of spring-loaded flapper and a housing.



SCAVENGE PUMP SCHEMATIC

FTX80722

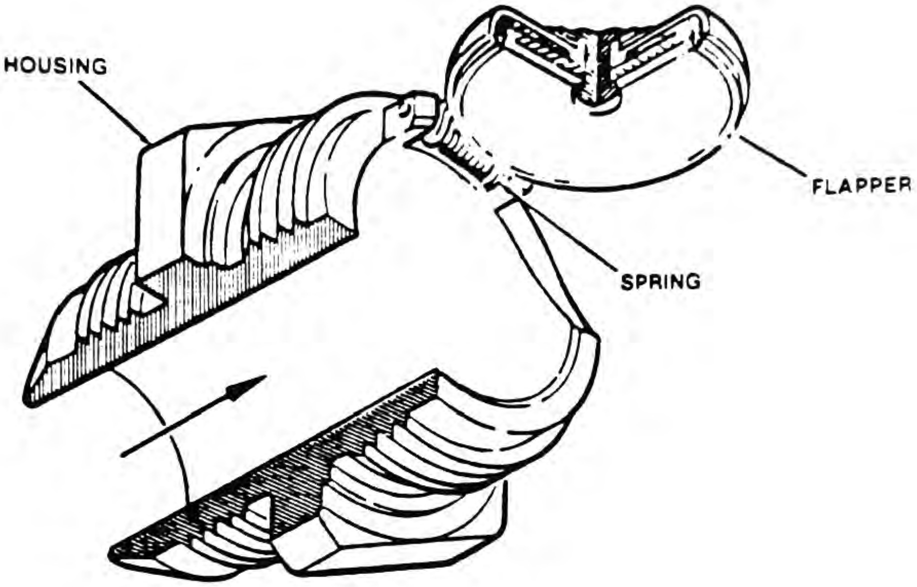
Figure 28-9



SCAVENGE PUMP SELECTOR VALVE - SCHEMATIC

FTX80723

Figure 28-10



FUEL RECIRCULATING CHECK VALVE - SCHEMATIC

FTX80724

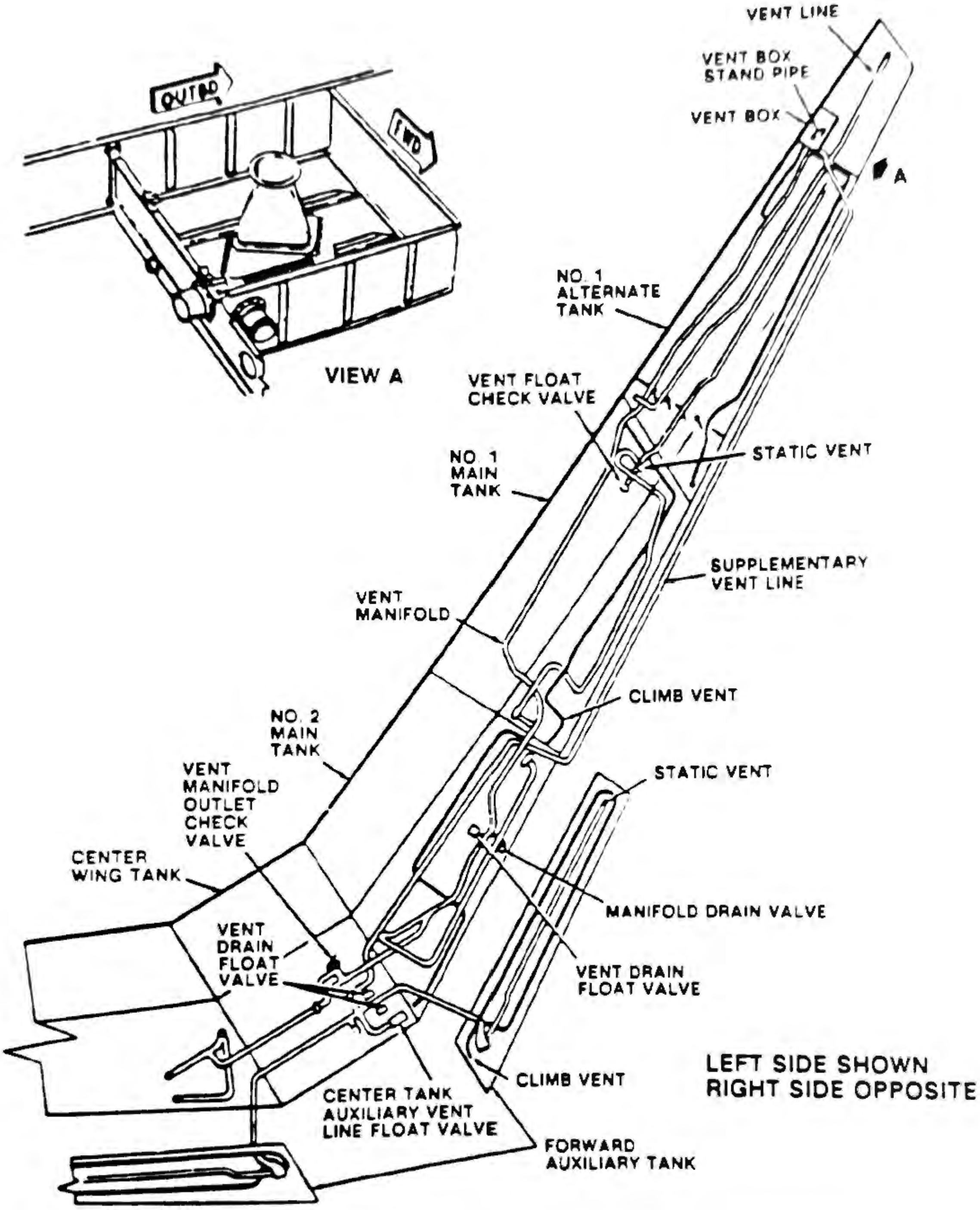
Figure 28-11

4. Description Vent System and Components

A. Vent System (See Figure 28-12)

(1) The fuel tank vent system provides venting from the tanks during tank refueling and airplane ascent, and into the tanks during fuel usage and descent. Venting prevents the development of an excessive pressure differential that could damage the wing structure. The vent system also prevents structural damage by allowing fuel to flow overboard from the tanks in the event of a tank overfilling due to a fill system malfunction.

(2) The vent system consists of four subsystems; a left wing subsystem, a right wing subsystem, a forward auxiliary vent subsystem, and a center wing tank vent subsystem. Each wing vent subsystem vents the main and alternate tanks of its respective wing. Although the two wing subsystems are interconnected, the center wing tank is primarily vented by the left wing subsystem. The forward auxiliary tank vent subsystem vents into the center wing tank. The center wing tank auxiliary vent subsystem vents the forward auxiliary and center wing tanks when the wing vent subsystem contains trapped fuel due to stepped climb. Each wing subsystem consists of a vent trap, a manifold which runs from the inboard tank to the vent trap, climb and static vents, and drain valves which tee into the manifold. The vent traps are located in the outboard alternate tanks and at high points in the system. The drain valves are located in the inboard main tanks and in the center wing tank, and are at the lowest points in the system. Each tank has a static vent and a climb vent which are connected into a common manifold. The vents are located so that one of the two vent inlets in each tank is exposed to the airspace above the fuel in any normal airplane attitude. The static vents are exposed to air during static, level flight, and descent attitudes. With full tanks, the climb vents are submerged when the airplane is in the static ground attitude but are exposed to air when the airplane is within a climb angle of 6 to 7 degrees (or equivalent level acceleration). Either of the two vents (but not both) may become submerged during certain roll attitudes, depending on the direction of roll. Drain lines connect low points in the static vent pipes to the manifold. There is a vent line connecting the inboard section of the outboard alternate tank with the outboard main tank. The inboard end of this line has a float valve installed. A combination fill and vent line connects the outboard



LEFT SIDE SHOWN
RIGHT SIDE OPPOSITE

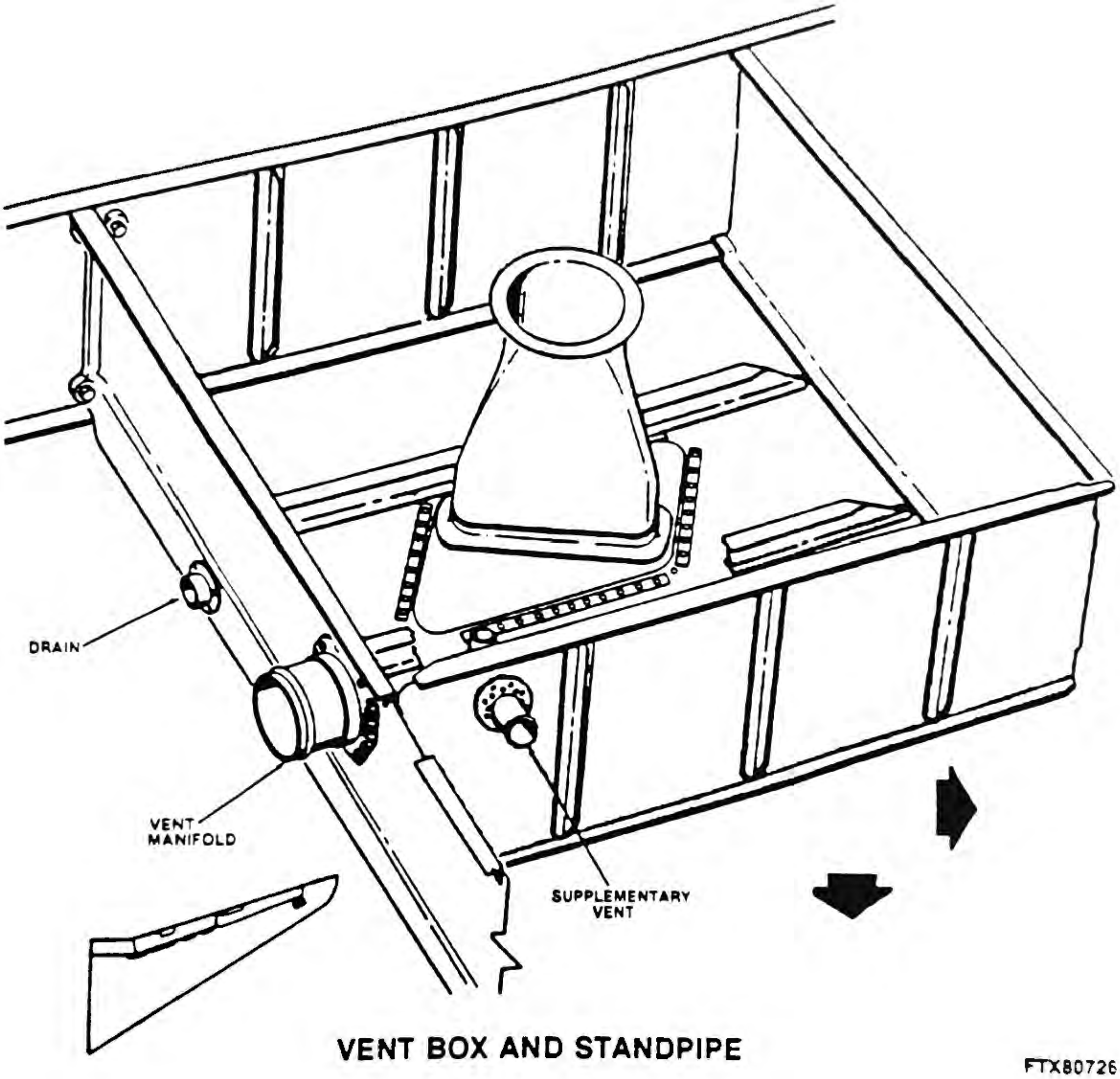
VENT SYSTEM AND COMPONENTS - SCHEMATIC

FTX80725

Figure 28-12

section of the outboard alternate tank with the inboard section reservoir. This line vents the outboard section into the inboard section which in turn is vented into the outboard main tank.

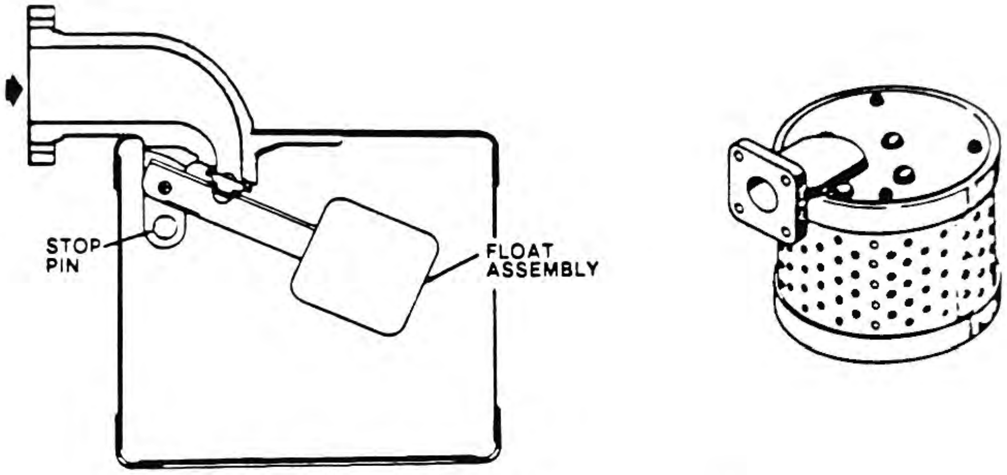
(3) The vent trap consists of a vent box and an overboard standpipe (See Figure 28-13) and has a capacity of approximately 200 pounds (30 gallons of fuel). This quantity is the total amount of fuel which will enter the tank static vents during climb and/or forward acceleration if all the tanks are full. When the airplane is leveled out, this fuel flows into the manifold and inboard into the tanks from which fuel is being used. However, if the airplane is immediately returned to an extreme climb angle, this fuel will flow outboard and fill the vent trap, but it will not spill overboard. A drain float valve is installed in main tanks No. 2 and 3, and two drain check valves are installed in the center wing auxiliary tank. If fuel level is below the 17,100 pound level in main tanks No. 2 and 3, or below the 24,000 pound level in center wing auxiliary tank, the drain float valve (or drain check valve) automatically drains liquid from the manifold into the tanks. A manual drain valve is installed in tanks No. 2 and 3. The manual drain valve is tool-operated and is used to drain sediment water overboard. Due to the common manifold, conditions of extreme thermal expansion may cause a small quantity of fuel to be displaced from the outboard to the inboard tanks if the tanks are full.



VENT BOX AND STANDPIPE

Figure 28-13

(4) There is one vent manifold drain float valve (See Figure 28-14) located in each inboard main tank. The valves are connected into the low points of the vent manifold. The valves automatically drain any sediment or fuel from the manifold into the alternate tanks when the fuel level in these tanks decreases to below approximately 17,100 pounds.



VENT MANFOLD DRAIN FLOAT VALVE

FTX80727

Figure 28-14

(5) The valve consists basically of a housing and a float. The float arm is attached to lugs to allow free swing. The self-aligning valve is attached to the top side of the arm and has a bonded seal that seats and mates to the attaching neck outlet opening. The float, which is seated or opened by the fuel level of the inboard alternate tanks, is held seated until approximately the drain level is reached. At this point the float lowers, opens the valve, and automatically drains the manifold into the tank.

B. Vent Manifold Manual Drain Valves

The vent manifold manual drain valves are installed, one each, in the inboard main tanks. The valves permit manual draining of the vent manifold during maintenance. The valves are identical to the sump drain valves except that the sump drain valves have a vent hole in the upper part of the valve housing.

C. Vent Float Check Valves (See Figure 28-15)

The vent float check valves are installed, one each, in the inboard end of the vent line between the inboard section of the outboard alternate tank and the outboard main tank. The valve prevents fuel from surging outboard during turns on the ground. The valve consists basically of a float operated flapper. When the valve float is submerged in fuel the flapper closes the vent line.

D. Vent Manifold Outlet Check Valve (See Figure 28-15)

There is one vent manifold outlet check valve installed in the vent line leading from the junction of the main vent lines in the center tank. The check valve is of the swing check type. The valve consists basically of a flapper pinned to a flange base. This valve prevents fuel from surging back into the vent line from the center tank.

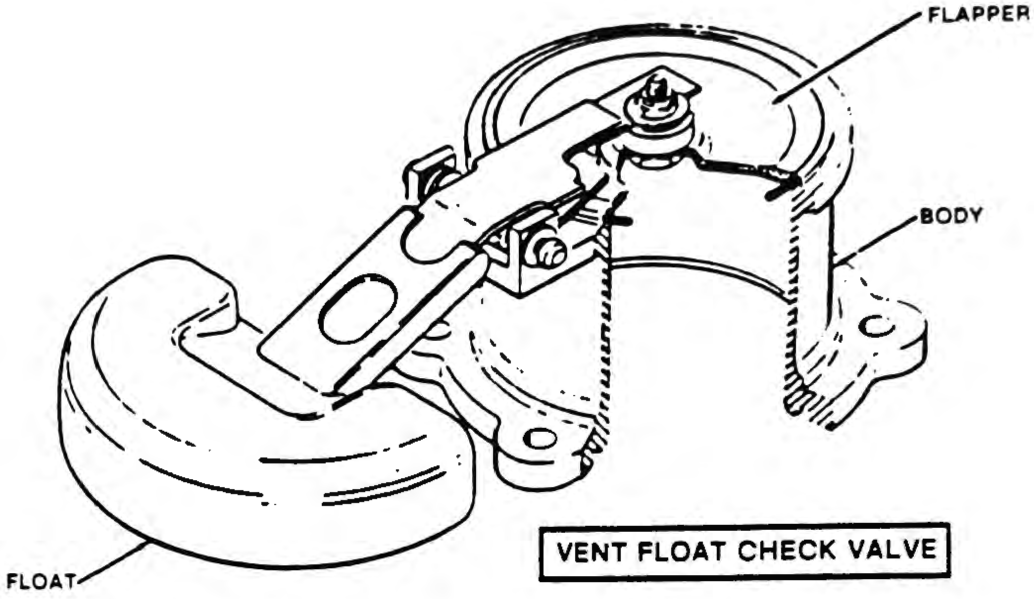
E. Center Tank Auxiliary Vent Line Float Check Valve (See Figure 28-16)

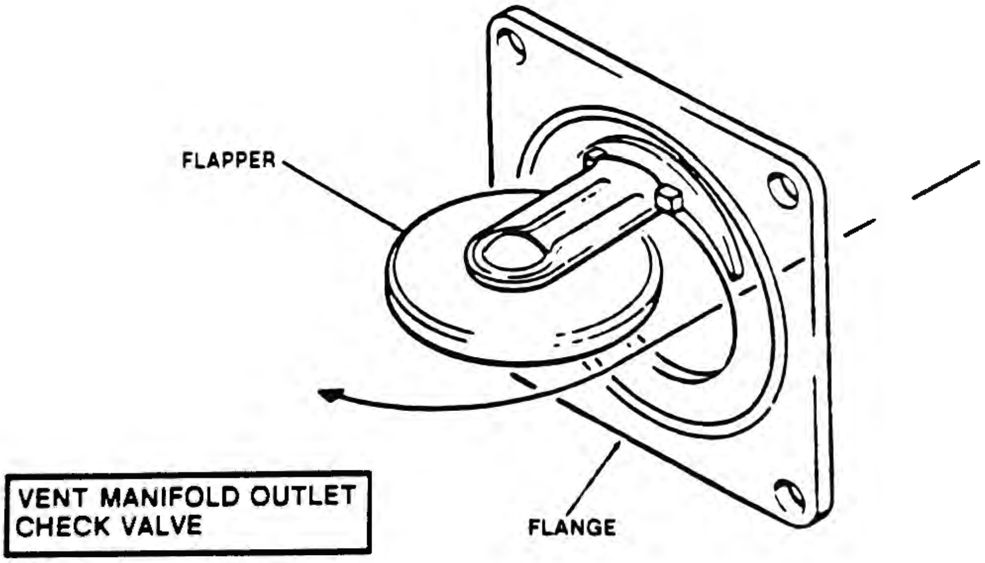
The center tank auxiliary vent float check valve is installed in the inboard end of the center tank auxiliary vent line in the center tank. The valve consists basically of a flapper attached by an arm to a counter-weighted float. The flapper assembly is hinged to a housing. A cage encloses the complete assembly. The valve is mounted near the upper surface of the tank. When the fuel level is below the level of the float the valve is open to provide venting. When the fuel surrounds the float the valve closes preventing loss of fuel.

5. Distribution - Description and Operation

A. General

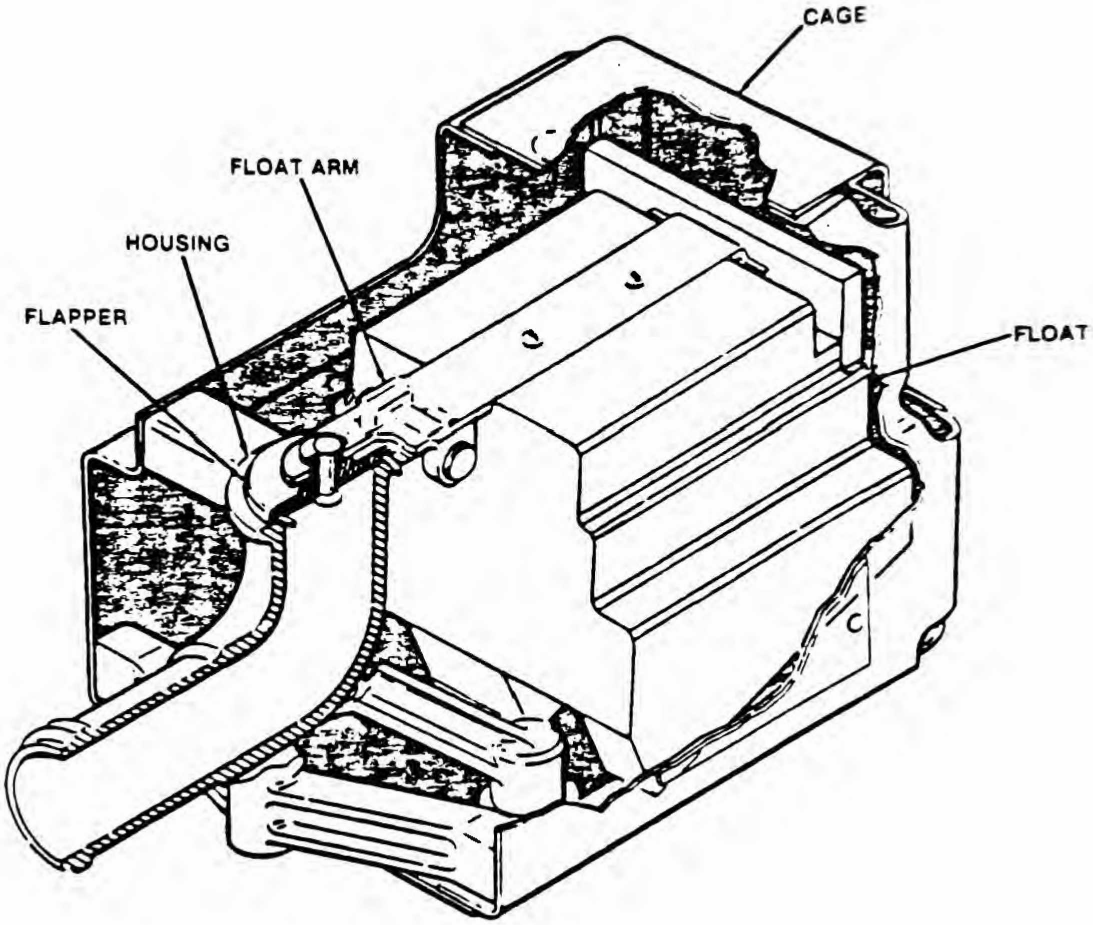
The fuel distribution system is divided into the fuel tank fill system and the engine fuel supply system. The fill system is concerned with the distribution and control of fuel from the pressure fueling adapters to the fuel tanks. The engine fuel supply system is concerned with the routing of fuel from the fuel tanks up to the engine driven fuel boost pump. The crossfeed manifold, which is considered a part of the distribution system, is





FTX80728

Figure 28-15



CENTER TANK AUXILIARY VENT LINE FLOAT CHECK VALVE

FTX80729

Figure 28-16

also used for pressure fueling. Further description and operation of the fill system and the supply system will be covered under individual sections for each system.

6. Fuel Tank Fill System - Description and Operation

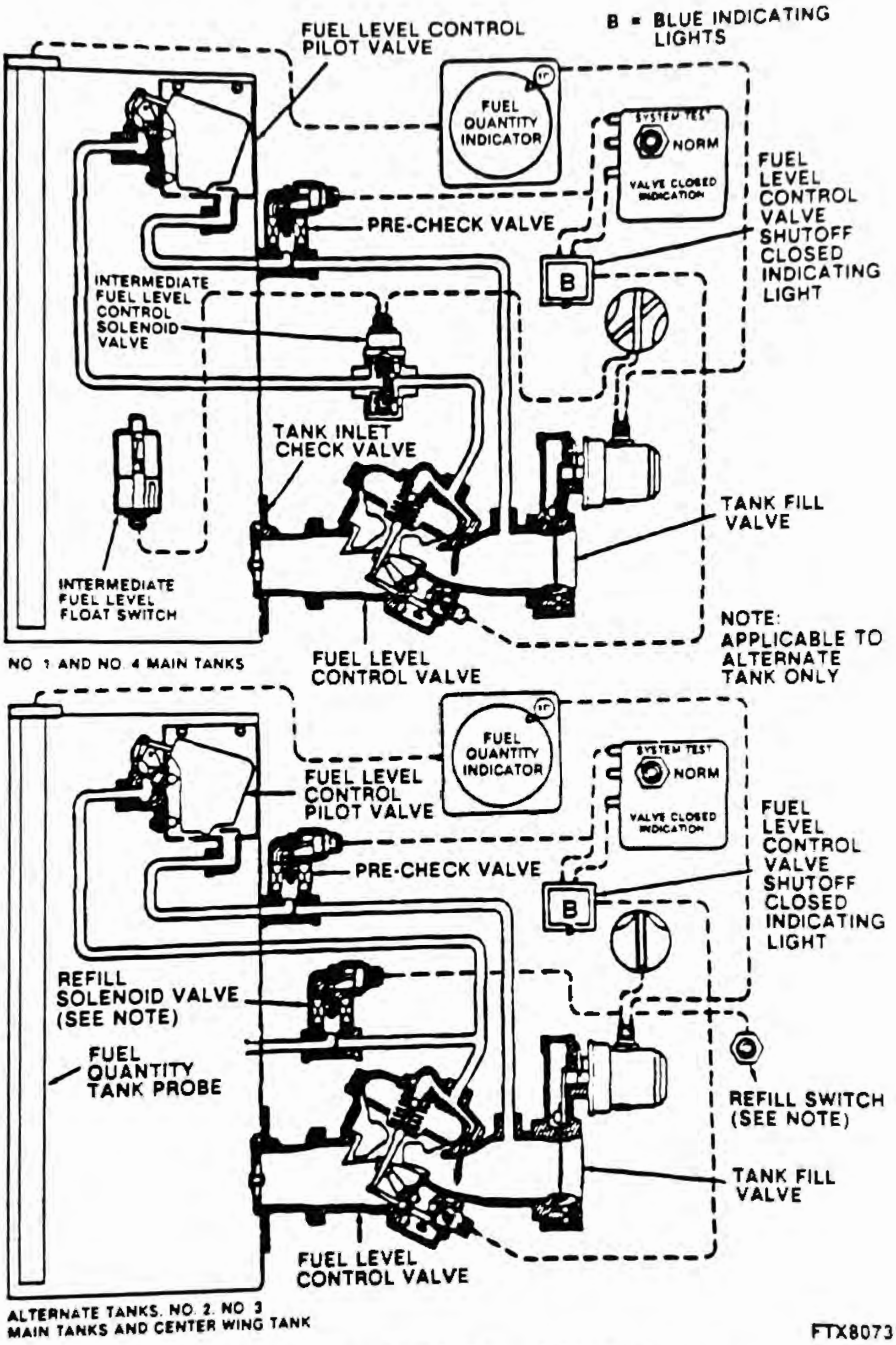
A. General

(1) The fuel tank fill system is comprised of typical tank subsystems consisting of components and controls that regulate tank filling (See Figure 28-17). Each tank subsystem consists basically of a tank fill (shutoff) valve, a fuel level control pilot valve, a fuel level control valve, a check valve, and a precheck valve (for checking system operation). The outboard alternate tank has a float valve in the outboard end of the "T" fill line. The outboard main tanks also have intermediate fuel level control solenoid valves and float switches installed. A line and a check valve are provided to bypass each outboard main tank selector valve to permit fuel to be transferred from the outboard main tanks to the corresponding outboard alternate tanks while still supplying fuel to the engine. Four pressure refueling adapters are installed in the wing leading edge. Alternate tank refill solenoid valves are installed between the fuel level control valve pilot line and the alternate tank.

(2) The fill valve permits the fuel to flow into the tank from the crossfeed manifold and is used during refueling and fuel transfer. The main tank fill valves are controlled by a rotary switch. The alternate, the forward auxiliary, and the center wing tank-fill valves are controlled by toggle switches. Switches are located on the systems engineer's fuel panel in the flight compartment. Power is supplied to the switches from the 28 VDC bus. The fill valve operation is also controlled by a set switch in the fuel quantity indicator. The desired fuel quantity is selected and the set switch position is adjusted by a set knob on the indicator face. The selected fuel quantity is indicated by a pointer on the indicator dial periphery. The switch is in series electrically, with the fill valve control switch on the systems engineer's fuel panel and the fill valve motor.

(3) Surge protection relief valves are installed in parallel with the No. 1 and 4 alternate tank fill valves and fuel level control valves. The surge protection relief valves relieve high surge pressures by allowing fuel flow into the No. 1 and 4 alternate tanks.

(16) The gravity fuel transfer level control valve (See Figure 28-19) in the outboard alternate tank closes the inboard end of the fill line as the fuel level in the reservoir rises. As the fuel level in the reservoir nears empty during fuel use, the valve opens.


FUEL LEVEL CONTROL PILOT VALVE
B = BLUE INDICATING LIGHTS
FUEL QUANTITY INDICATOR
SYSTEM TEST
NORM
VALVE CLOSED INDICATION
FUEL LEVEL CONTROL VALVE SHUTOFF CLOSED INDICATING LIGHT
PRE-CHECK VALVE
B
INTERMEDIATE FUEL LEVEL CONTROL SOLENOID VALVE
TANK INLET CHECK VALVE
TANK FILL VALVE
INTERMEDIATE FUEL LEVEL FLOAT SWITCH
NOTE: APPLICABLE TO ALTERNATE TANK ONLY
NO. 1 AND NO. 4 MAIN TANKS
FUEL LEVEL CONTROL VALVE
FUEL QUANTITY INDICATOR
SYSTEM TEST
NORM
VALVE CLOSED INDICATION
FUEL LEVEL CONTROL PILOT VALVE
FUEL LEVEL CONTROL VALVE SHUTOFF CLOSED INDICATING LIGHT
PRE-CHECK VALVE
B
REFILL SOLENOID VALVE (SEE NOTE)
FUEL QUANTITY TANK PROBE
REFILL SWITCH (SEE NOTE)
TANK FILL VALVE
FUEL LEVEL CONTROL VALVE
ALTERNATE TANKS. NO. 2, NO. 3 MAIN TANKS AND CENTER WING TANK
FTX80731

TANK FILL SYSTEM - SCHEMATIC

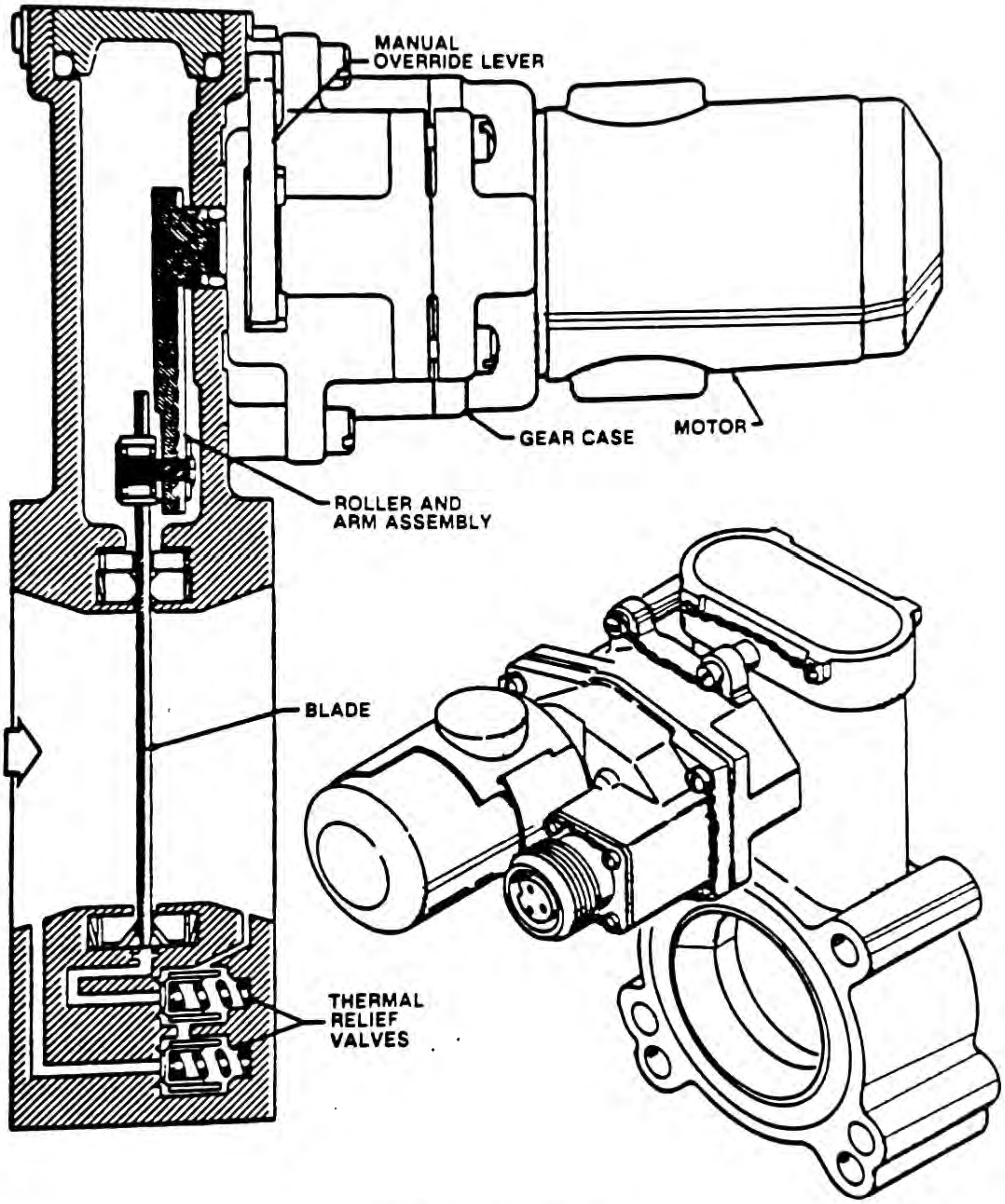
Figure 28-17

(4) The fuel level control valve is a pressure-operated, poppet-type valve used during refueling and fuel transfer to automatically stop fuel flow when the tank reaches the full level. It is controlled by two pressure-sensing lines connected to the inlet side of the valve. An internal microswitch grounds the corresponding shut-off closed indicating light when the valve closes.

(5) A dual push-to-test light assembly, consisting of a light for the corresponding tank fuel level control valve, is located on the systems engineer's fuel control panel and indicates that the fuel level control valve is closed. Each light is placarded SHUT-OFF CLOSED, with its corresponding tank number included.

(6) All tanks except the forward auxiliary tank have a fuel level control pilot valve connected by two lines, pilot and precheck, to the fuel level control valve. The pilot valve controls the pressure in the upper chamber of the control valve causing the control valve to open or close.

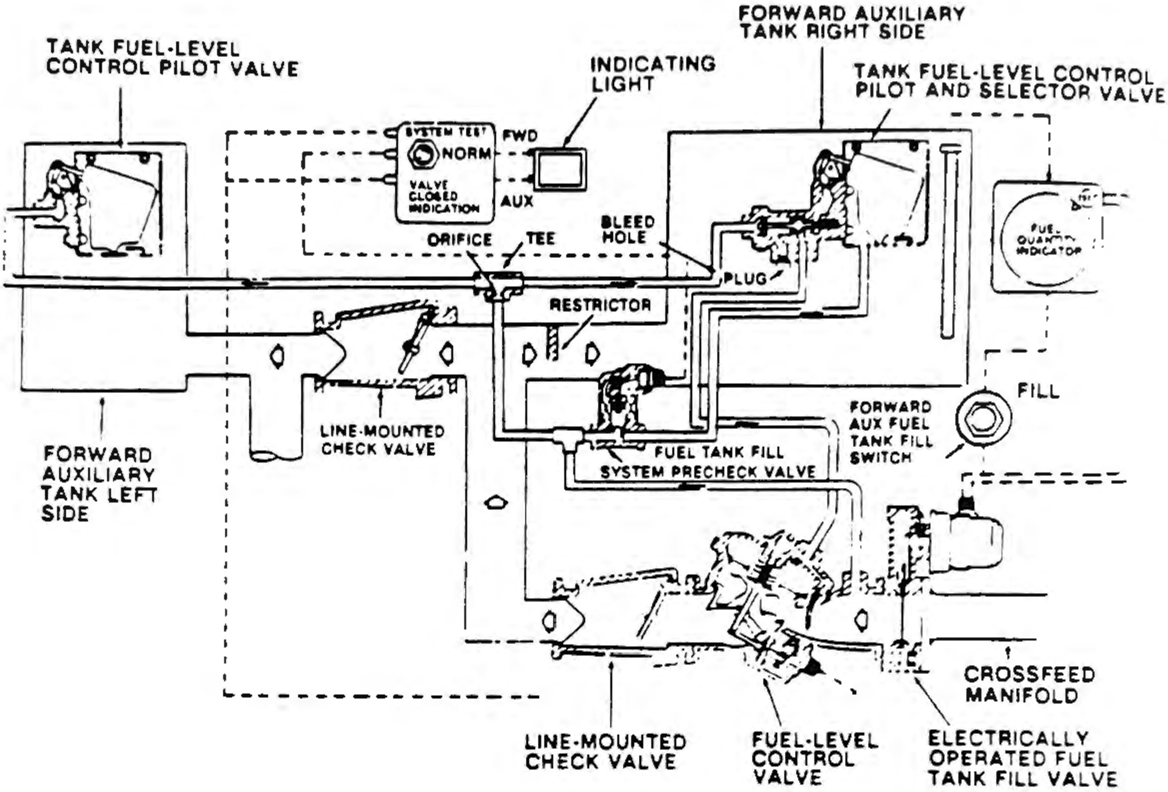
(7) The forward auxiliary tank has two pilot valves (See Figure 28-18),a fuel level control pilot valve located in the left side of the tank and a fuel level control pilot and selector valve located in the right side of the tank. These two valves assure that the fuel level control valve will shut-off regardless of which wing is low. A restrictor is provided in the inlet line of the right side of the tank to provide an equal fill rate for both sides. The fuel level control valve is controlled by the right side pilot and selector valve. When the pilot and selector valve closes at the tank-full level (right side low), back pressure in the pilot line closes the fuel level control valve. When the left side is low, and the tank-full level is reached: the left side pilot valve closes, the selector valve in the pilot and selector valve actuates, and the fuel level control valve closes. To accomplish this, the line connecting the two pilot valves is pressurized with fuel from the fuel level control valve inlet. When the left side pilot valve closes, back pressure in the line connecting the two pilot valves actuates the selector valve in the pilot and selector valve. The actuated selector valve causes back pressure in the pilot line which closes the fuel level control valve. An orifice is provided between the line connecting the pilot valves and the inlet to the fuel level control valve to reduce the pressure to that required for proper system operation. A bleed hole in the interconnecting line bleeds air from the line to assure that the right side pilot and selector



TANK FILL VALVE

FTX80735

Figure 28-21


FORWARD AUXILIARY TANK RIGHT SIDE
TANK FUEL-LEVEL CONTROL PILOT VALVE
INDICATING LIGHT
TANK FUEL-LEVEL CONTROL PILOT AND SELECTOR VALVE
SYSTEM TEST
NORM
VALVE CLOSED INDICATION
FWD
AUX
ORIFICE
TEE
BLEED HOLE
PLUG
RESTRICTOR
FUEL QUANTITY INDICATOR
FILL
FORWARD AUX FUEL TANK FILL SWITCH
FUEL TANK FILL SYSTEM PRECHECK VALVE
LINE-MOUNTED CHECK VALVE
FORWARD AUXILIARY TANK LEFT SIDE
CROSSFEED MANIFOLD
LINE-MOUNTED CHECK VALVE
FUEL-LEVEL CONTROL VALVE
ELECTRICALLY OPERATED FUEL TANK FILL VALVE

TANK FILL SYSTEM - SCHEMATIC

FTX80732

Figure 28-18

valve will not operate due to only a static fuel head. static fuel head could occur, for example, when the left wing is high. At this time the fuel and air contained in the line connecting the two pilot valves would pressurize the selector valve, if the entrapped air were not bled off.

(8) A precheck system valve in the precheck line is controlled by the fuel tank automatic shutoff system switch located on the systems engineer's fuel control panel in the flight compartment. This system

simulates a full tank and checks the automatic shutoff function of the fuel level control valve. The tank fill system precheck valve is located in the wing leading edge.

(9) Each of the outboard main tanks has a float switch installed at approximately the 2800 pound fuel level in the tank. The float switch is electrically connected to the intermediate level solenoid valve in the sensing line leading to the fuel level control valve.

(10) The intermediate fuel level control solenoid valve, activated by the float switch, controls the fuel level control valve sensing line pressure.

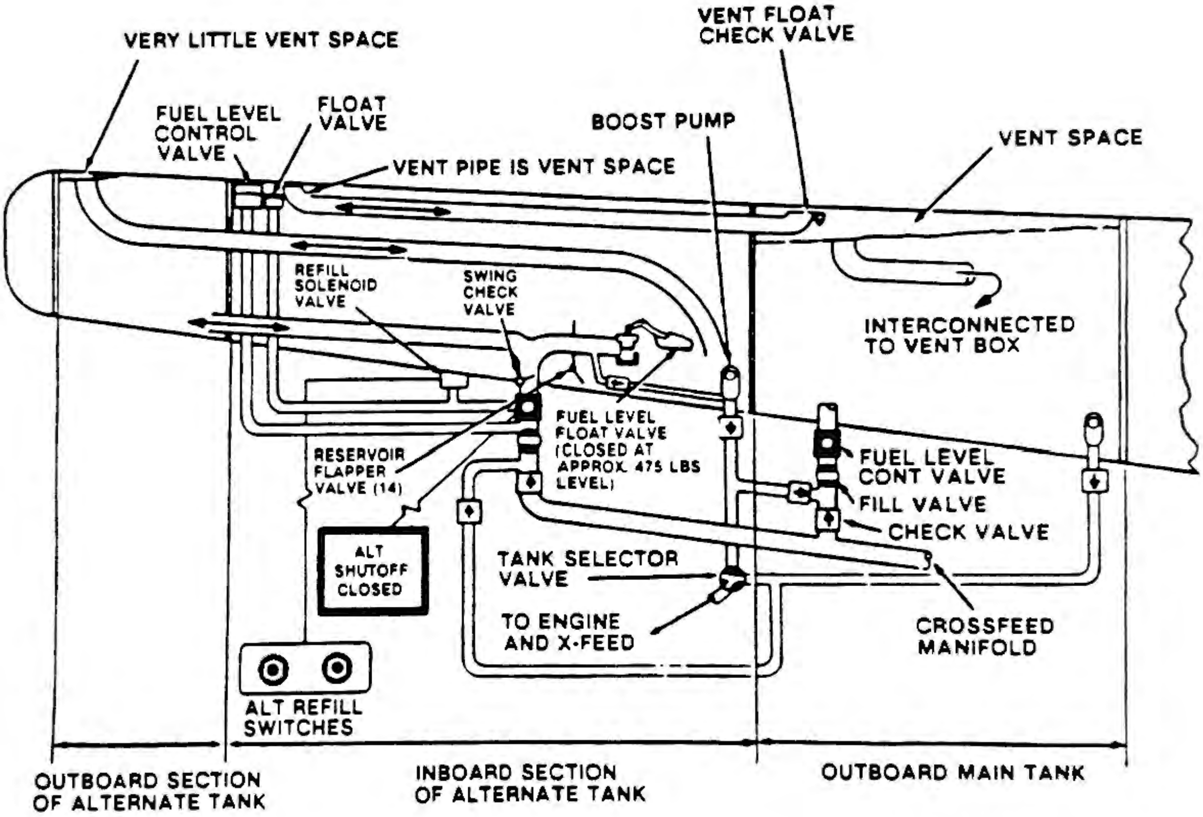
(11) The alternate tank refill solenoid valve bleeds pilot line pressure to the alternate tank fuel level control valve.

(12) The inlet check valves prevent reverse flow of fuel from the tanks into the fill lines.

(13) The fuel tank shutoff indicating and test system is used during refueling to indicate operation of the fuel level control valves and to test system operation. The system consists of a toggle switch, blue dual indication lights, precheck valves, and fuel level control valve microswitches.

(14) The fuel quantity indicator set switches are preset by the set knob on the indicators to close the fill valves at a predetermined fuel quantity. The fill valve switches can override the indicator set switches at any time and close the fill valves. The indicator set switches are normally used only during refueling.

(15) The pressure refueling adapters connect directly into the crossfeed manifold. The adapters include an integral check valve to prevent backflow when the refueling nozzle is disconnected. The valve is opened by connecting the nozzle to the adapter. For under-wing pressure refueling, the system's initial fill rate is 1400 gpm at 50 psig maximum with all tanks filling from four adapters. The adapters include a dashpot and valve assembly that reduces any pressure surges emanating from the ground fueling equipment. Caps are installed on the adapters when they are not in use.



ALTERNATE TANK FILL AND VENT

FTX80733

Figure 28-19

come spring force and start opening the valve. The initial opening rate is controlled, due to the flow rate through the ball check and around the stem, from the larger upper chamber to the smaller. As the valve continues to open, the slot in the stem moves up into the smaller chamber, increasing the opening rate until the valve seats in the full open position. The first initial movement of the valve toward the open position lifts the lower stem off the microswitch actuating lever, allowing the switch to open.

(d) The valve remains in full open position until the upper chambers, venting through the pilot line, are closed by a float. This allows an increase of pressure in the chambers which, with the spring force, closes the valve. The opening and closing rate of the valve is from 2 to 5 seconds.

(4) Fuel Tank Fill System Precheck Valve (See Figure 28-23)

(a) There is one precheck valve for each tank fill system, located in the precheck line between the fuel level control valve and the fuel level control pilot valve. The precheck valve has an inlet port, and outlet port, and an electrical connector. It is a solenoid-opened, spring-loaded-closed, poppet-type valve.

(b) When the solenoid is energized, the poppet is withdrawn from the valve body permitting fuel to flow through.

(5) Tank Inlet Check Valve (See Figure 28-23)

(a) There is one tank inlet check valve in each fill line located downstream of the fuel level control valve in the wing leading edge. The check valve is a spring-loaded-closed, self-aligning, flapper-type valve. The flapper assembly consists of a hinge pin, swing arm, and a flapper with integral seat seal. The hinge pin mounts the swing arm to the valve housing. A light torsion spring between the arm and the hinge pin support bracket normally holds the flapper seated. The check valve is mounted in the line to allow fuel to flow into the tank but not from the tank into the fill line.

B. Description

(1) Pressure Refueling Adapter (See Figure 28-20)

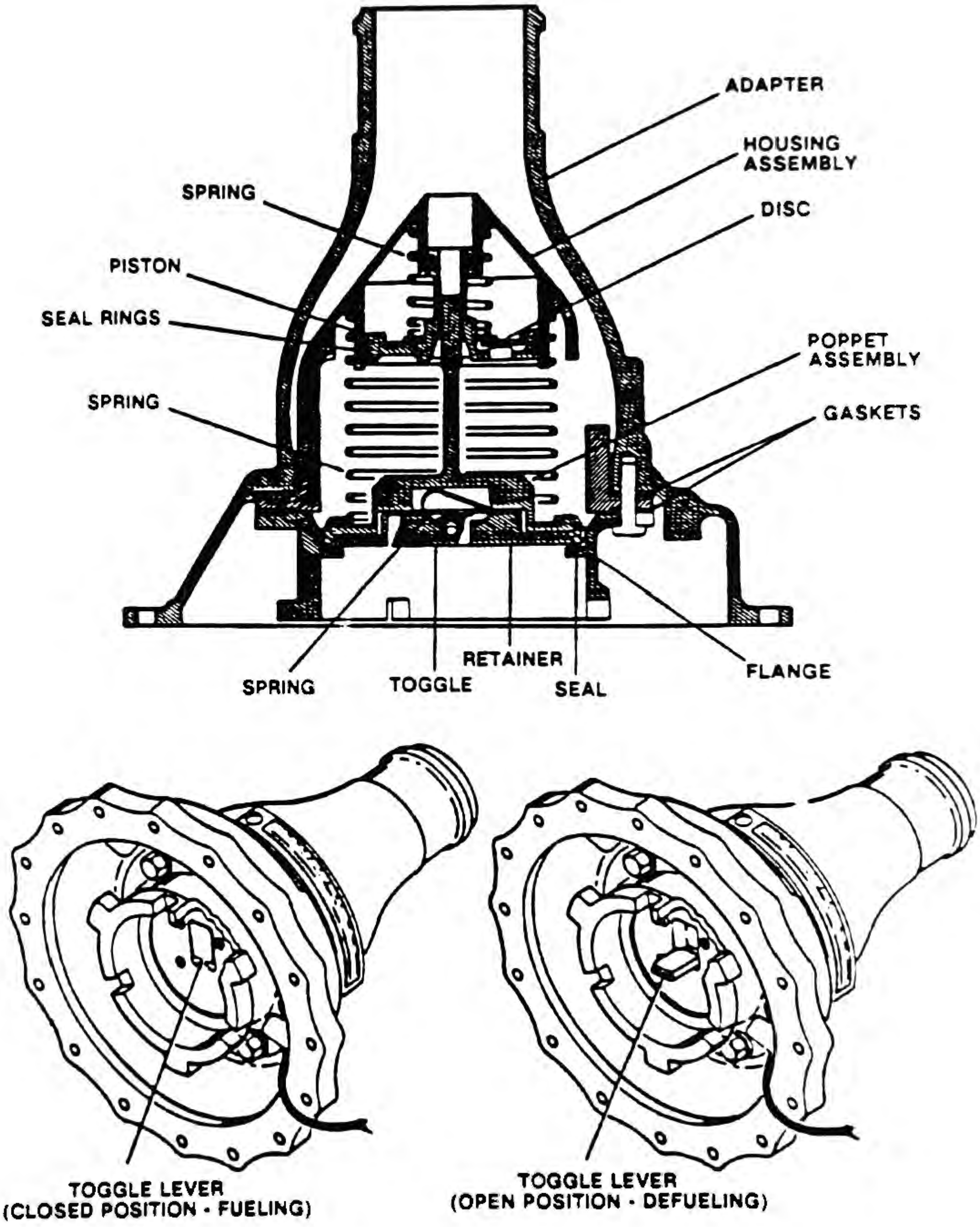
(a) The four pressure refueling adapters are used to connect the ground fueling and defueling equipment to the airplane. Each adapter consists of a toggle lever, housing, dashpot piston, dashpot valve, and poppet valve. The dashpot piston and dashpot valve action reduces the initial surge pressures emanating from the ground fueling equipment. The poppet valve prevents inadvertent reverse fuel flow through the adapter.

(b) The fuel entering from the ground service nozzle builds up pressure against the poppet valve, which has been moved into contact with the dashpot piston by the ground fueling nozzle valve. As the pressure increases, the poppet valve forces the dashpot piston against the spring and the fuel trapped in the dashpot chamber. The dashpot check valve is held closed and the fuel in the chamber is forced out by controlled leakage around the dashpot piston. The controlled leakage retards the movement of the poppet valve. Any reverse fuel flow pressure that is greater than the incoming fuel flow pressure will close the poppet valve.

(c) Defueling is accomplished by manually setting the toggle lever on the adapter to the spring-loaded open position. This causes the poppet valve to be lifted off its seat by the ground fueling nozzle valve. Fuel then flows from the crossfeed manifold into the ground defueling equipment.

(2) Tank Fill Valve (See Figure 28-21)

(a) The tank fill valves are DC motor-operated, gate-type valves. The valves are line-mounted and located adjacent to the fuel level control valves at the corresponding fuel tank. Fuel can flow through the valves into the tanks from the crossfeed manifold. Each valve consists of a motor, a housing, a blade, a gear train actuator, a roller and arm, a manual override lever, and two thermal relief valves.



PRESSURE REFUELING ADAPTER - SCHEMATIC

FTX80734

Figure 28-20

(b) The motor, through the gear train actuator, moves the slide blade in the housing. Movement of the blade allows or stops the fuel flow through the valve. The manual override lever is placarded to indicate the open and closed position of the valve. The two thermal relief valves relieve excessive pressure buildups in the piping because of thermal expansion of trapped fuel. The relief valves crack open at 60 (±5) psi and close at approximately 35 psi.

(3) Fuel Level Control Valve (See Figure 28-22)

(a) There is one fuel level control valve in each tank inlet line. The valve has an inlet port, an outlet port, a precheck port, and a pilot port. The valve has an internal microswitch which is actuated when the valve is closed.

(b) The valve poppet is positioned at an angle in the housing to either completely seat and close off the outlet or to move upward and allow full flow through the valve. A bleed hole relieves any possible vacuum that could be created between the closing of the shutoff valve and the closing of the swing check valve. A return spring between the upper housing and the top face of the valve normally holds the valve down and seated. A diaphragm divides the chamber into an upper and lower section. A normally open switch closes when the valve is full closed. A curved pressure pickup tube has its inlet facing upstream in the valve inlet chamber. The tube is connected to a small chamber in the upper housing. The pilot line junctions into this same passage. A check valve between the upper valve chamber and this passage allows rapid valve opening but seats to restrict the closing rate.

(c) The valve opens when fuel pressure enters the lower valve chamber and acts on the bottom side of the diaphragm and seated valve area. This pressure causes the diaphragm to move toward the upper chamber, forcing fuel up through the check valve into the smaller upper chamber. Fuel pressure also enters through the pick-up tube at lower pressure, due to an orifice reducing the pressure. If the pilot line is not closed by a float or solenoid valve in the tank, the fuel pressure in the upper chambers will vent to atmosphere in the tank. The area of the diaphragm being greater than that of the seated valve will have sufficient force to over-

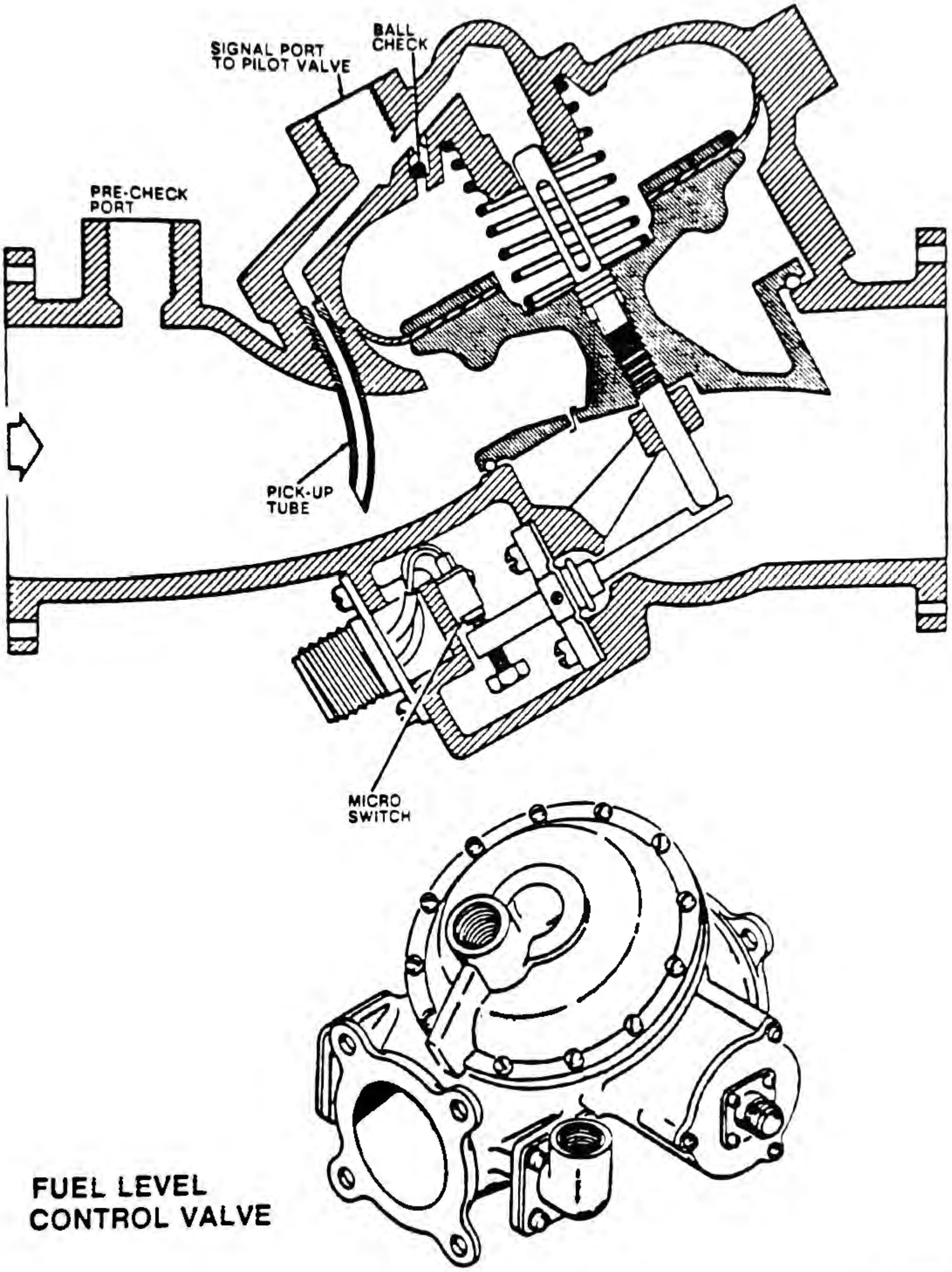
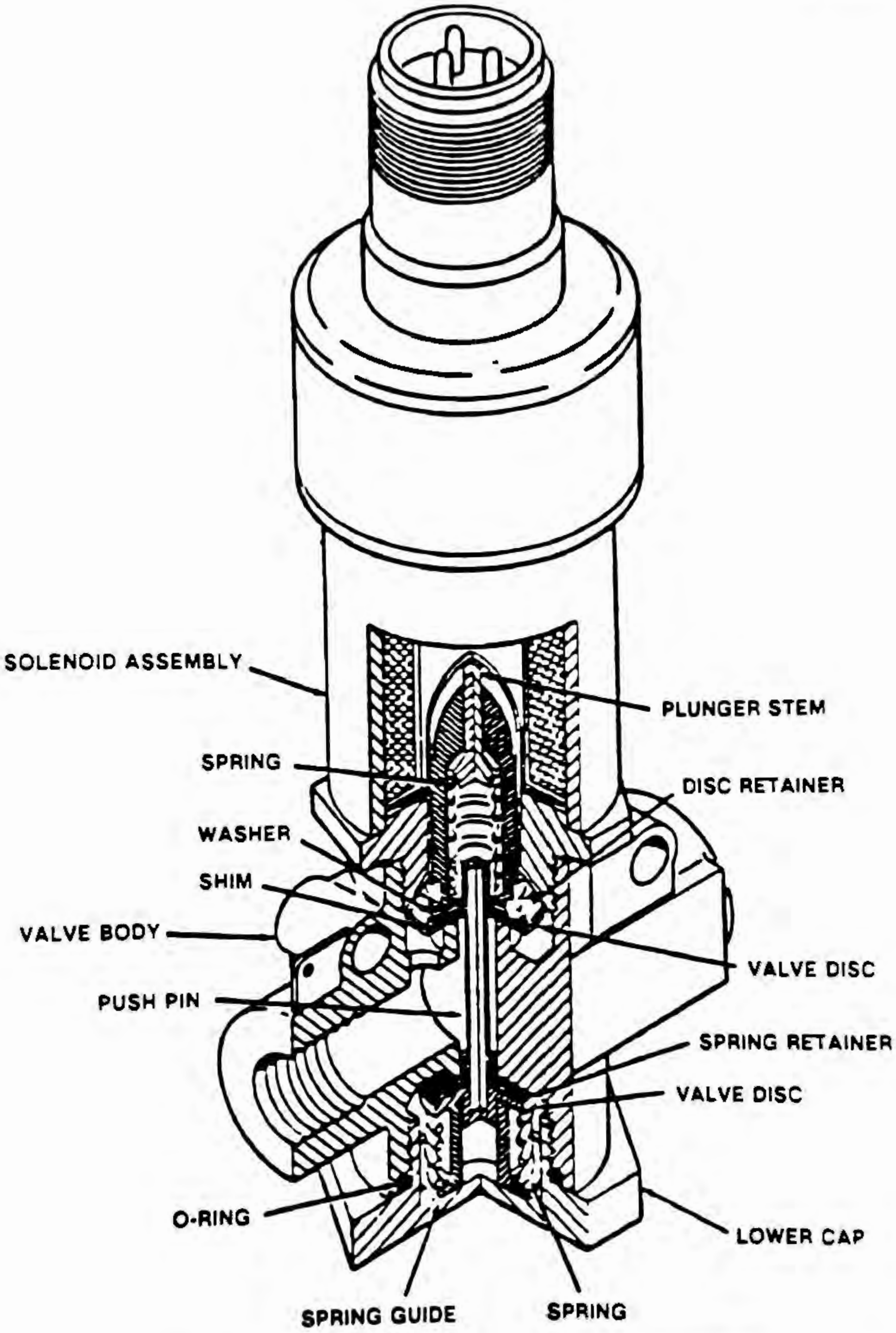

SIGNAL PORT TO PILOT VALVE
BALL CHECK
PRE-CHECK PORT
PICK-UP TUBE
MICRO SWITCH
FUEL LEVEL CONTROL VALVE
FTX80736

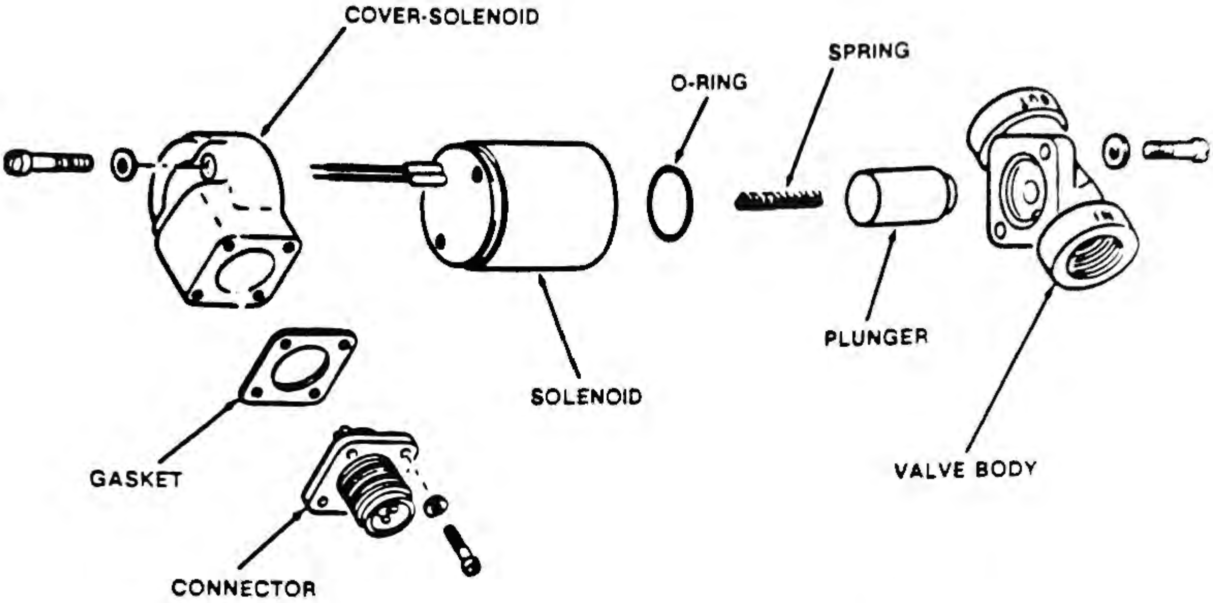
Figure 28-22



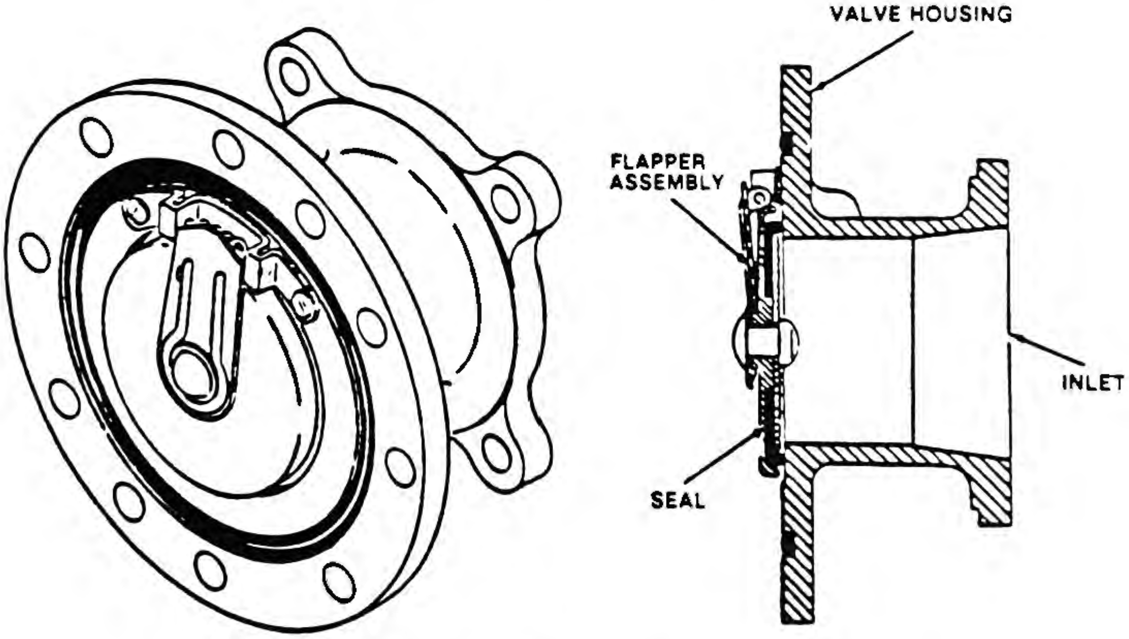
INTERMEDIATE FUEL LEVEL CONTROL
SOLENOID VALVE - SCHEMATIC

FTX80741

Figure 28-27



FUEL TANK FILL SYSTEM PRECHECK VALVE - SCHEMATIC



TANK INLET CHECK VALVE - SCHEMATIC

FTX80737

Figure 28-23

(b) Fuel pressure through the inlet port opens the flapper and fuel can flow into the tank. Removal of pressure against the flapper allows the flapper to swing to the closed position, preventing fuel from flowing back through the fill line.

(6) Fuel Level Control Pilot Valve (See Figure 28-24)

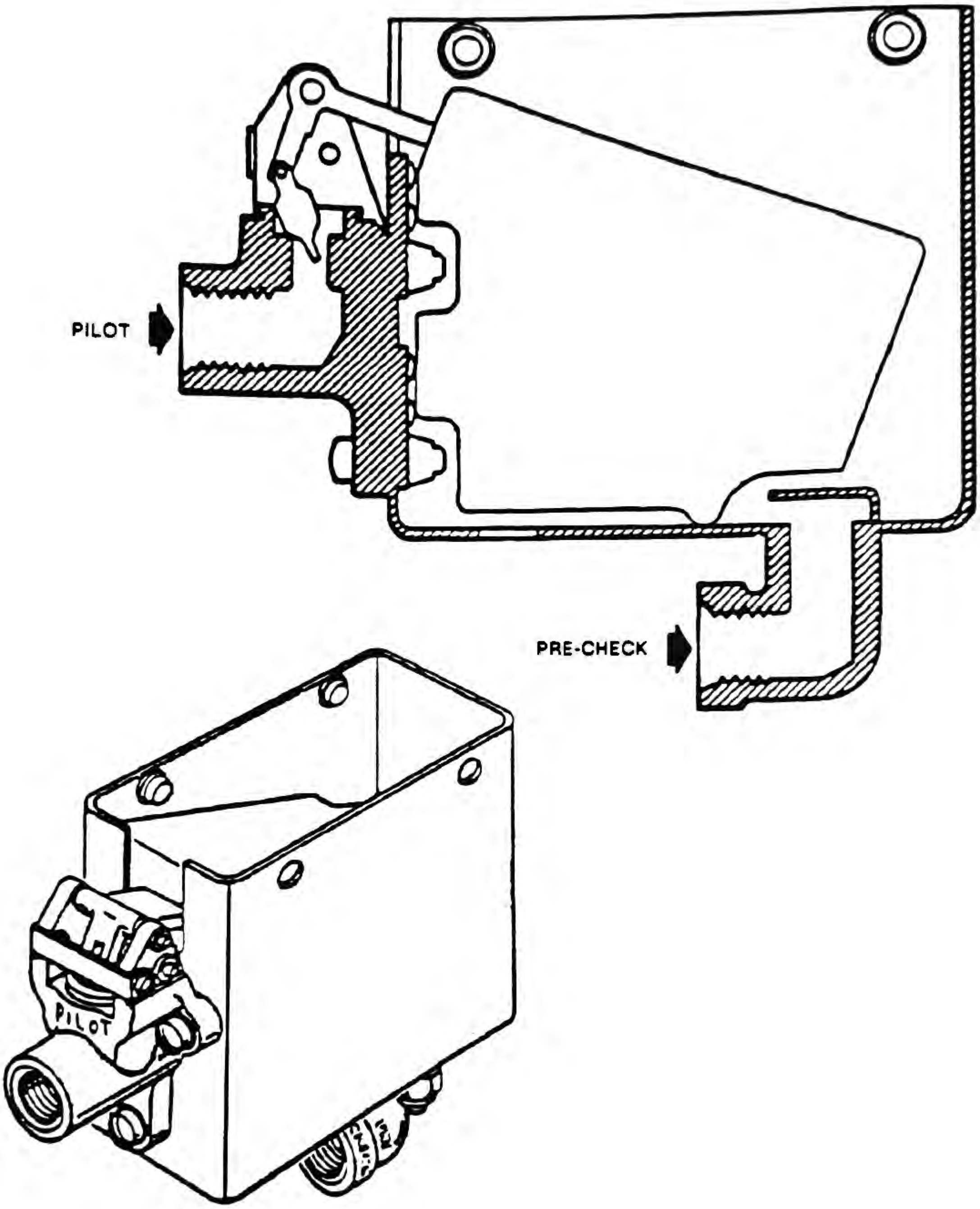
(a) The fuel level control pilot valve is a float-operated needle valve. The valve normally is either seated or opened by tank fuel levels. The valve consists of a metal can, float assembly, and needle valve. The can has a fill and drain hole, a precheck line port, and a pilot line port. A deflector tab that is inside the can, over the precheck inlet port, diffuses the entering stream of fuel during precheck test to prevent it from acting directly on the float.

(b) During tank filling, the float will be down, holding the needle valve open. Fuel flows from the open fuel level control valve pilot line back into the tank. As the tank fuel level reaches the valve, the fill and drain hole in the can allows the fuel to enter and seek the tank level. When the float fully seats the valve, the fuel level control valve closes stopping the flow of fuel from the fuel level control valve pilot line back into the tank. To test the operation of the valve, the solenoid valve is opened in the precheck line allowing fuel to enter the can through the precheck fitting. This fills the can and simulates a full tank, seating the pilot valve.

(7) Fuel Level Control Pilot and Selector Valve (See Figure 28-25)

(a) The fuel level control pilot and selector valve is a float-operated needle valve with pressure-operated plunger-type shuttle. The valve normally is either seated or allowed to open by tank full-fuel levels. This controls fuel pressure in the upper chambers of the fuel level control valve and will either allow it to open or cause it to close. By this means the filling to the full fuel levels can be controlled in the forward auxiliary tank of the airplane.

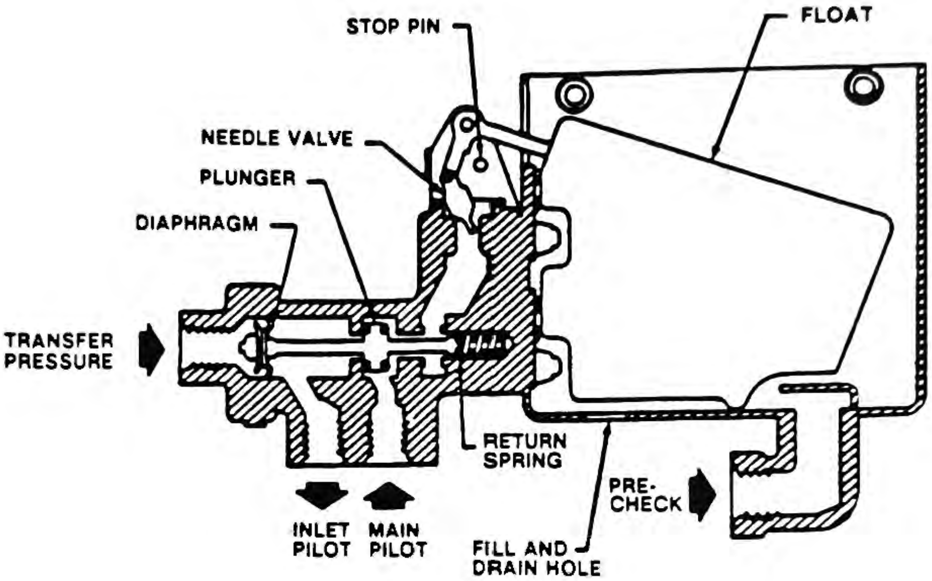
(b) The valve consists of a metal can, float assembly, and attaching fittings. The can is open at the top. The bottom side of the can has a fill and drain hole and also a fitting for attaching the precheck line. A deflector tab, which is inside the can over the precheck inlet port, diffuses the entering stream of fuel during precheck test to prevent it from acting directly on the float.



FUEL LEVEL CONTROL PILOT VALVE - SCHEMATIC

FTX80738

Figure 28-24



FUEL LEVEL CONTROL PILOT AND SELECTOR

FTX80739

Figure 28-25

(c) The housing also has the needle valve seat, the support lugs for the float arm, and the integral selector valve. The needle valve attaches to the one end of the float arm and is self-aligning to the seat that is threaded into the housing. The other end of the arm is secured in the float itself. A stop pin through the support lugs prevents the float from lifting and moving the arm past the valve closed position. A protrusion on the valve prevents it from becoming misaligned with the seating port. A stop heel on the bottom of the float also aids in preventing the valve from being completely lifted out of the port.

(d) The middle portion of the valve has a double seating selector or plunger. The position of the selector determines whether fuel is directed to the integral float-operated needle valve or to the intermediate level control valve.

(e) During initial tank filling, the float is down against the bottom of the can, holding the needle valve open. Fuel then is able to flow from the fuel level control valve, through the main pilot port, and into the selector valve chamber. The plunger, being seated by spring force, directs the fuel up through the open needle valve port and back into the tank. As the tank fuel level reaches the valve, the fill and drain hole in the can allows it to enter and seek the tank level. When the tank level is approximately 1/4 inch from the top of the can, the float has the needle valve fully seated (closed). This causes the fuel level control valve to close, stopping the filling of the tank.

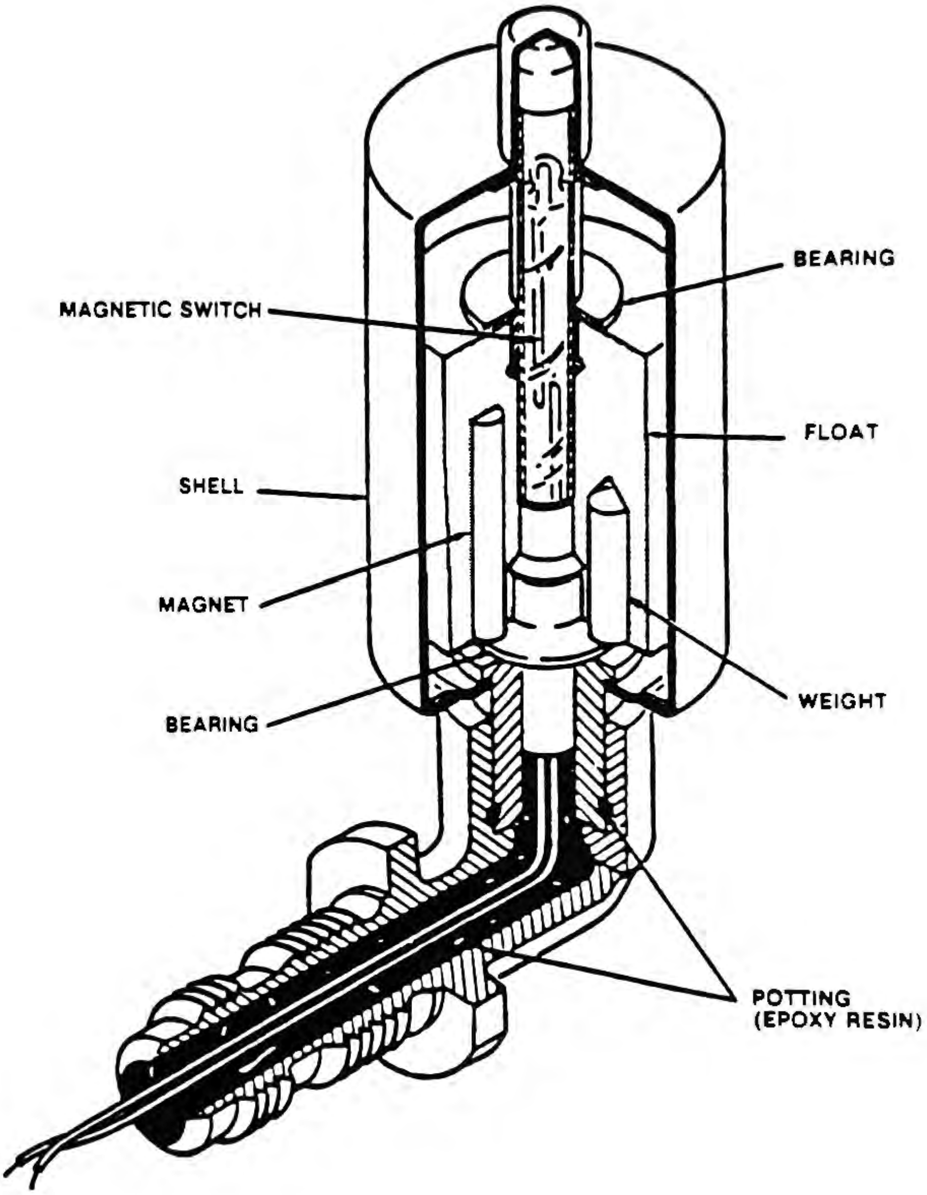
(f) To test the operation of the pilot and selector valve and the fuel level control valve while the tank is filling, the precheck line is opened by a solenoid valve allowing fuel to enter the can through the precheck fitting. This fills the can and simulates a full tank, seating the pilot valve, which causes the control valve to close.

(8) Intermediate Fuel Level Float Switch (See Figure 28-26)

(a) The intermediate fuel level float switches are float-operated magnetic switches located in the No. 1 and No. 4 main tanks to automatically control and maintain, with the aid of solenoid valves, the intermediate fuel level. Each switch consists basically of a hermetically sealed glass enclosed switch, float-supported magnets, and a perforated aluminum shell.

(b) A rise of the fuel level in the tank causes the float to rise. This in turn causes the magnetic switch to close, completing the circuit to the intermediate fuel level control solenoid valve. As the fuel level drops below the switch level the switch will open, breaking the circuit to the solenoid valve.

(9) Intermediate Fuel Level Control Solenoid Valve (See Figure 28-27)



INTERMEDIATE FUEL LEVEL FLOAT SWITCH - SCHEMATIC

FTX80740

Figure 28-26

(a) The intermediate fuel level control solenoid valves are located in the No. 1 and No. 4 main tanks to control, with the aid of the intermediate fuel level float switches, the intermediate fuel level in the No. 1 and No. 4 main tanks. The solenoid valves consists basically of a solenoid operated valve disc assembly. The valve is normally open, but closes when the solenoid is energized by the closing of the float switch.

(b) When the solenoid valve closes, venting pressure from the control valve pilot line is stopped causing a pressure buildup in the fuel level control valve upper housing, which in turn causes the control valve to close.

(10) Surge Protection Relief Valve (See Figure 28-28)

(a) The surge protection relief valves are located on the front spar, outboard of the outboard pylons in parallel with the No. 1 and 4 alternate fuel tank fill valves and fuel-level control valves. Each surge protection relief valve consists of the housing, piston, and bleed poppet valve. The relief valve opens at 150 psig and closes at 135 psig.

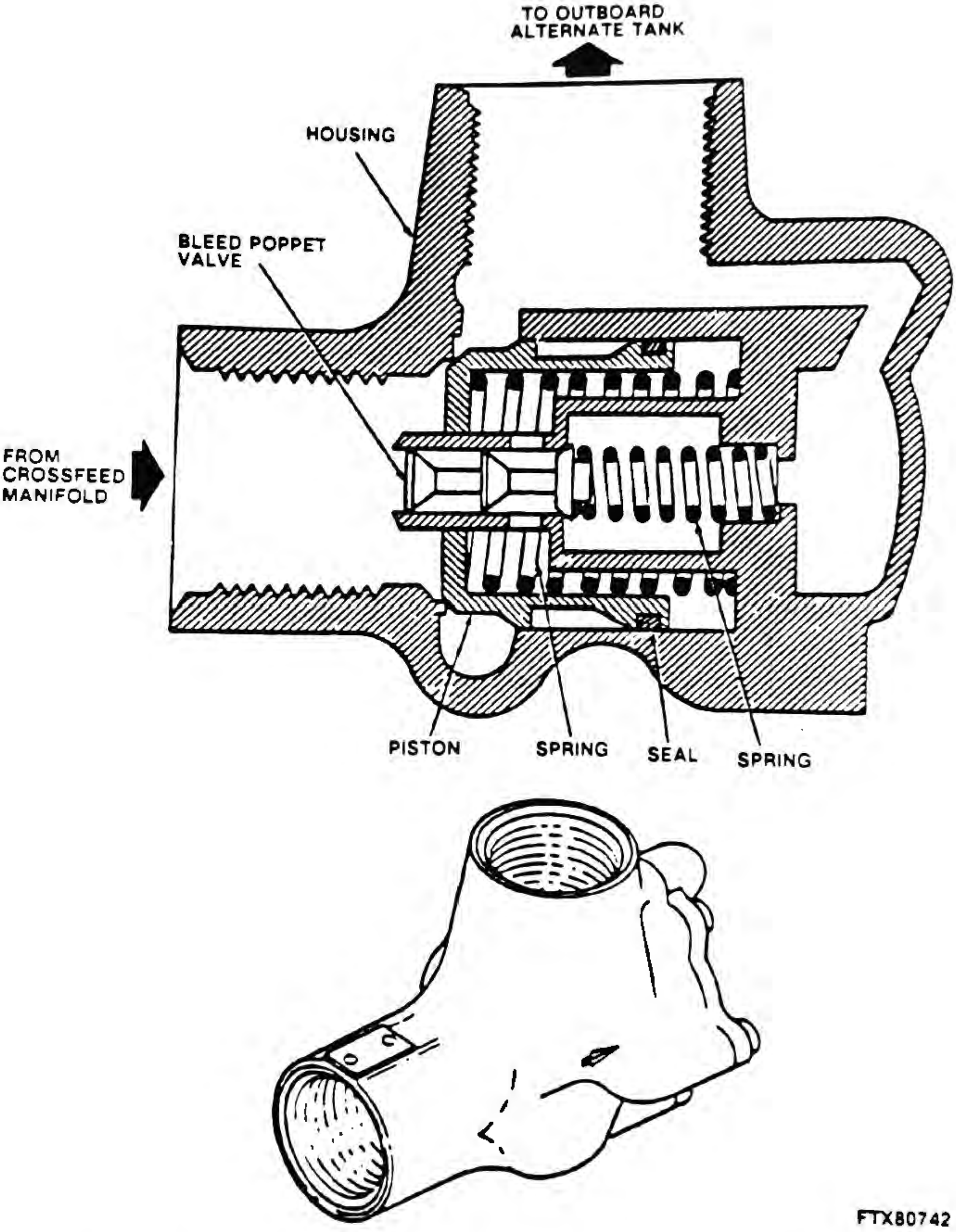
(b) The valves protect the fuel system against the high surge pressures created during the ground fueling operation. The excess pressures are relieved through the relief valves into the No. 1 and 4 alternate fuel tanks, bypassing the No. 1 and 4 alternate tank fill valves and the fuel level control valve.

(11) Alternate Tank Refill Solenoid Valve

The refill solenoid valve is identical to the precheck valve.

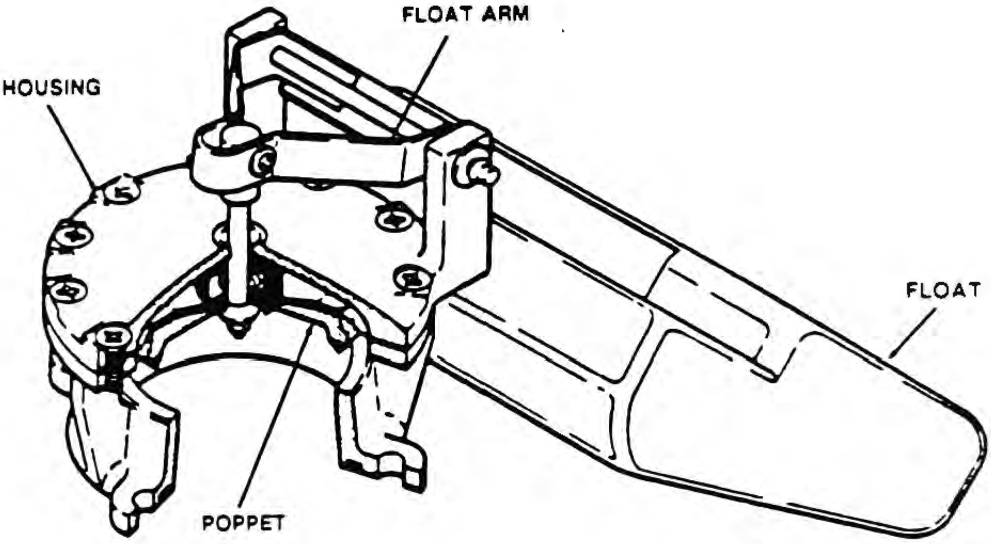
(12) Gravity Fuel Transfer Level Control Valve (See Figure 28-29)

The gravity fuel transfer level control valves are installed, one each, in the inboard end of the outboard alternate tank fill line. The valve closes the end of the fill line and causes the outboard section of the alternate tank to be filled first. The valve consists basically of a float arm operated poppet enclosed in a housing. As the fuel level rises around the valve the float rises. As the float arm closes the valve line



SURGE PROTECTION RELIEF VALVE - SCHEMATIC

Figure 28-28



GRAVITY FUEL TRANSFER LEVEL CONTROL VALVE - SCHEMATIC

FTX80743

Figure 28-29

pressure enters the area above the poppet diaphragm and aids in closing and holding closed the poppet.

C. Operation

(1) When the tank fill valves are opened, fuel from the crossfeed manifold flows through the fill valves, the fuel level control valves, and the tank inlet check valves into the tanks. Fuel also flows from each fuel level control valve to the respective fuel level control pilot valve. When the full-tank level is reached, the pilot valve closes the control valve through the pressure buildup in the sensing line.

(2) When a full tank is not desired, the setting of the fuel quantity gage set knob to the desired fuel load automatically closes the fill valve when the desired quantity is reached.

(3) The tank fill valve electrical control system provides the systems engineer with manual and automatic control over the gate-type tank fill valves. This control system has three modes of operation; refueling, in-flight fuel transfer, and intermediate level control (No. 1 and No. 4 main tanks only). During refueling, the fill valves can be controlled either by the fill valve switches or the fuel quantity indicator set switches.

(4) During refueling, the fill valves are controlled automatically by the fuel quantity indicator set switches. In this operation, the fill valve switches are placed in the fill position and the indicator switches set to the desired fuel quantity. When the desired fuel quantity has been reached, the indicator set switch is actuated. Power is then supplied through the fill valve switch and the indicator switch to close the fill valve. Once the set switch has functioned, the fill valve cannot be opened electrically except by adjusting the indicator set pointer to a greater fuel quantity than the one selected.

NOTE: If the fuel quantity indicator is removed from the fill valve control circuit, the fill valve may be closed, but not opened, by the fill valve switch on the system engineer's fuel control panel.

(5) In flight during fuel transfer, the fill valves are controlled by the fill valve switches. This operation is the same as refueling using the fill valve switches.

(6) Intermediate fuel level control (No. 1 and No. 4 main tanks only) is achieved by means of the intermediate fuel level float switch and solenoid valve. With the tank fill switch in the intermediate level position, the tank fill valve will open permitting fuel to be transferred into the tank. When the fuel level rises to approximately 2800 pounds the float switch is closed energizing the normally open solenoid valve. The energized solenoid valve closes. This in turn causes a back pressure to build up in the pressure line from the control valve dome, in turn closing the fuel level control valve.

(7) When the tank refill solenoid valve switch is actuated, the solenoid valve opens, bleeding the pressure to the fuel level control valve back into the fuel tank. The control valve then opens permitting fuel to be transferred into the outboard section of the outboard alternate tank.

(8) When the automatic shutoff system switch is placed in the system test position, power is supplied to the shutoff valve closed lights and the precheck valves. With the precheck valves energized, fuel flows to the float-operated fuel-level control pilot valves causing the pilot valves to close. A back pressure is then built up to close the fuel-level control valve, which actuates its integral switch completing the ground circuit for the indicating lights. It is necessary to hold the automatic shutoff system switch in the system test position during this operation.

(9) As the fuel level in the reservoir in the inboard section of the outboard tank rises the low level fill float valve closes causing the incoming fuel to fill the outboard section of the outboard alternate tank first. As this tank becomes full, fuel is then routed through the combination fill and vent line between the inboard and outboard sections into the reservoir. As the fuel level in the inboard section nears empty during fuel use, the float valve opens and permits more fuel from the outboard section to flow into the reservoir for further transfer to the supply system.

(10) When the automatic shutoff system switch is placed in the valve closed indication position, power is supplied to the indicating lights. When a fuel tank becomes full, the fuel-level control pilot valve closes causing the fuel level control valve to close. Closing of the fuel level control valve actuates the integral switch in the control valve completing the ground circuit for the indicating lights.

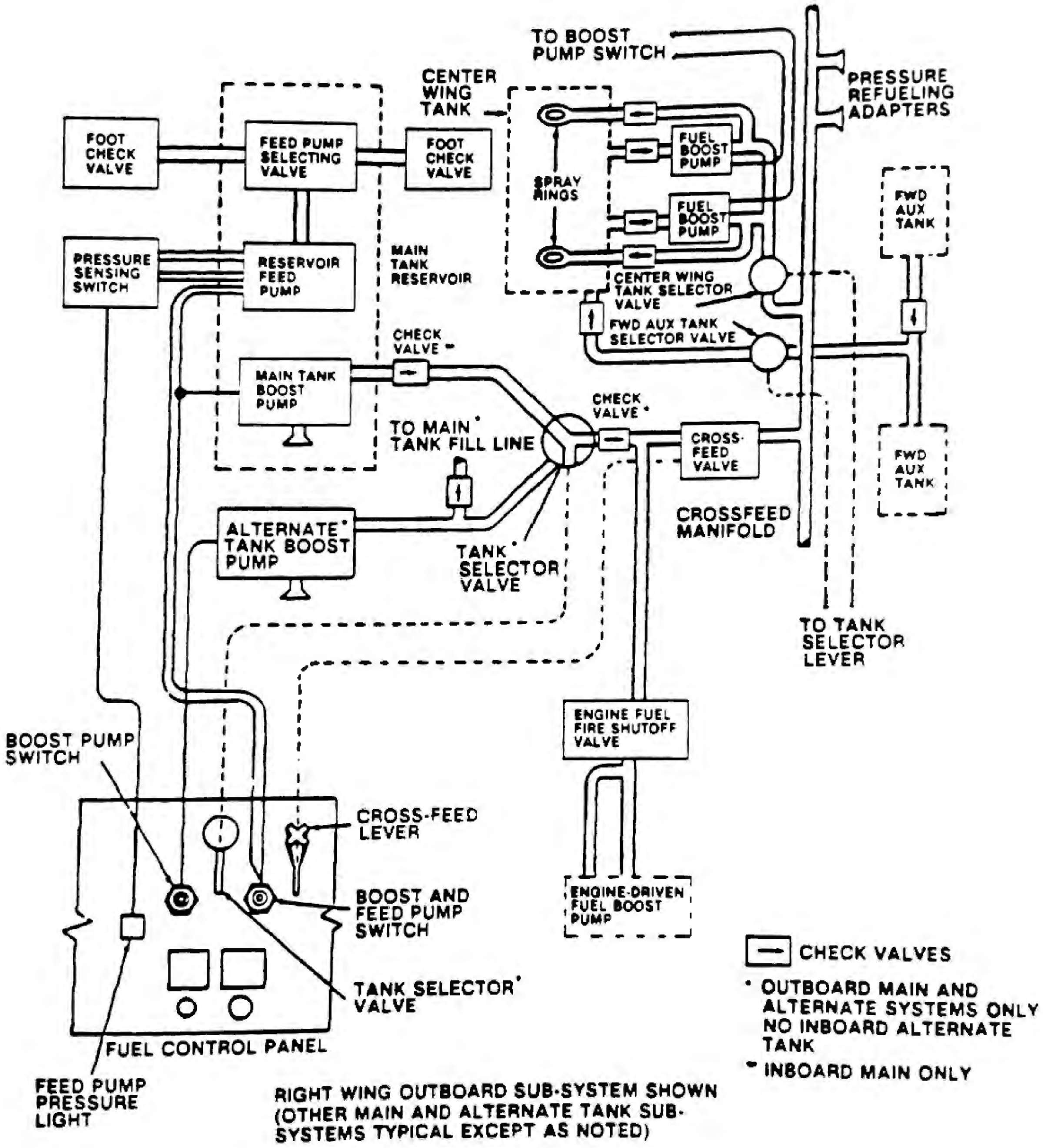
7. Engine Fuel Supply System - Description and Operation

A. General (See Figures 28-30 and 28-31)

(1) The engine fuel supply system routes fuel from the tanks to the engines. The major components of the system are located in the fuel tanks and the wing leading edge. The system controls are located on the systems engineer's control panel in the flight compartment. The engine fuel supply system is made up of four independent subsystems, one for each engine. By use of a crossfeed system, an independent system can supply fuel to any or all of the other independent systems. The supply system includes the tank fuel boost pumps, tank selector valves, crossfeed valves, crossfeed manifold drain valve, engine fuel fire shutoff valves, line-mounted check valves, and the necessary connecting fuel lines.

(2) Each main tank is provided with an integral reservoir to ensure that the main tank boost pump, which is mounted in the bottom of the reservoir, will be submerged when the airplane is in extreme attitudes, or accelerating, or when the fuel level is low. Fuel is supplied to the reservoir either through 1-way flapper check valves in the reservoir sides or by a feed pump located in the reservoir. Fuel to the feed pump is supplied through either of two foot check valves and an inlet selecting valve. The feed pump and boost pump are controlled by a common 3-position switch located on the systems engineer's control panel. The main and alternate tank selector valve permits either the main or the alternate tank to supply fuel to the system. The center wing tank and the forward auxiliary tank valves are manually operated gate valves that open or close the respective tank discharge lines. The center tank line discharges fuel into the supply system. The forward auxiliary tank line discharges fuel into the center tank. The selector valve is controlled by a lever on the systems engineer's control panel through cables and mechanical linkage. The crossfeed valve and the engine fuel fire shutoff valve, are 2-position, mechanically operated valves. The crossfeed valves are operated by levers on the systems engineer's control panel through cables and mechanical linkage. The engine fuel fire shutoff valve is operated through cable and mechanical linkage by the fire control handle located in the overhead panel in the flight compartment. A line is also installed to permit transfer of fuel from the No. 1 and No. 4 main tanks to the cor-

responding alternate tank without utilizing the crossfeed system. This transfer may be accomplished while supplying fuel to the corresponding engine.



* OUTBOARD MAIN AND ALTERNATE SYSTEMS ONLY NO INBOARD ALTERNATE TANK

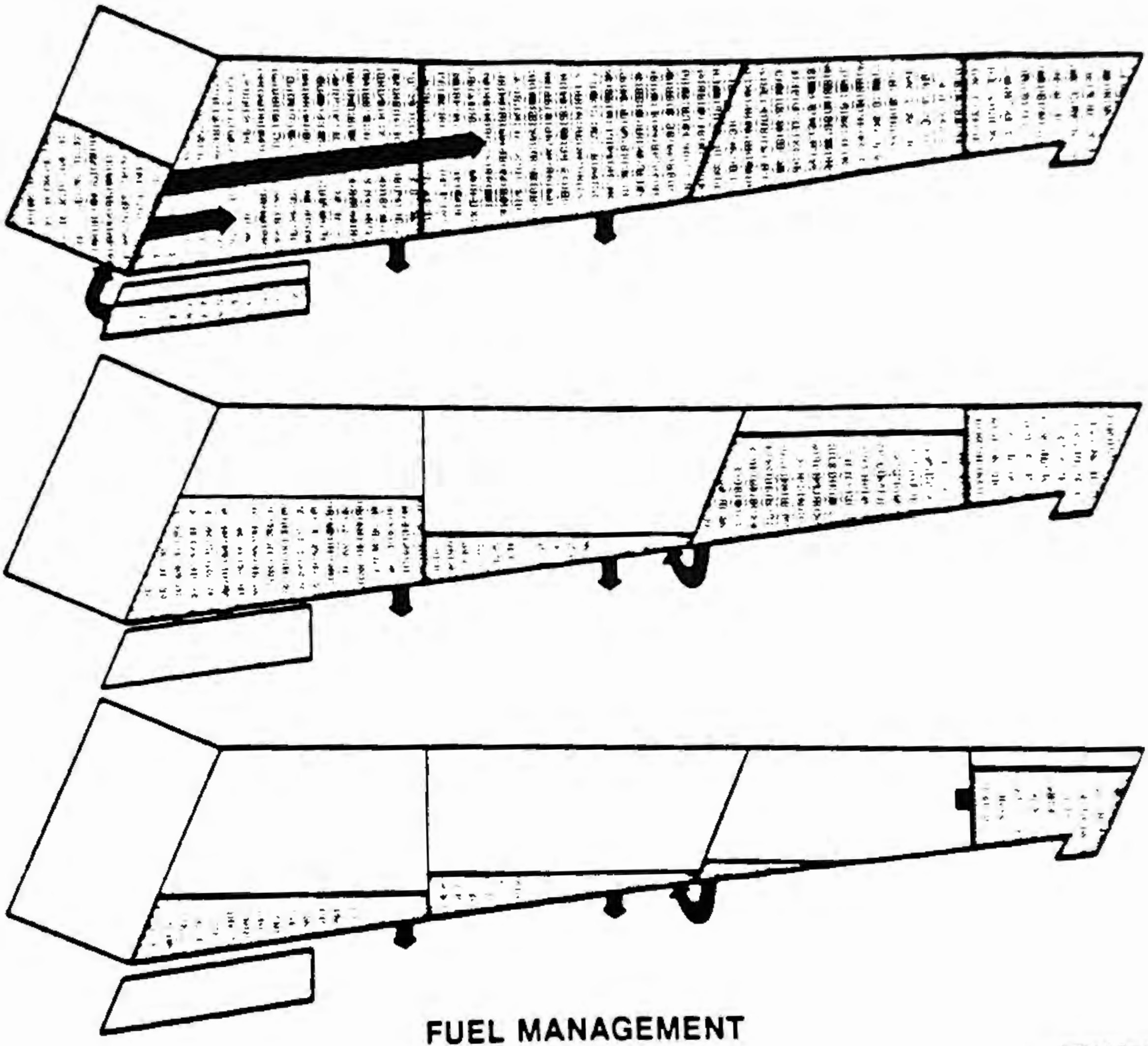
** INBOARD MAIN ONLY

RIGHT WING OUTBOARD SUB-SYSTEM SHOWN (OTHER MAIN AND ALTERNATE TANK SUB-SYSTEMS TYPICAL EXCEPT AS NOTED)

ENGINE FUEL SUPPLY SYSTEM - FUNCTIONAL SCHEMATIC

FTX80744

Figure 28-30



FUEL MANAGEMENT

FTX80745

Figure 28-31

B. Description

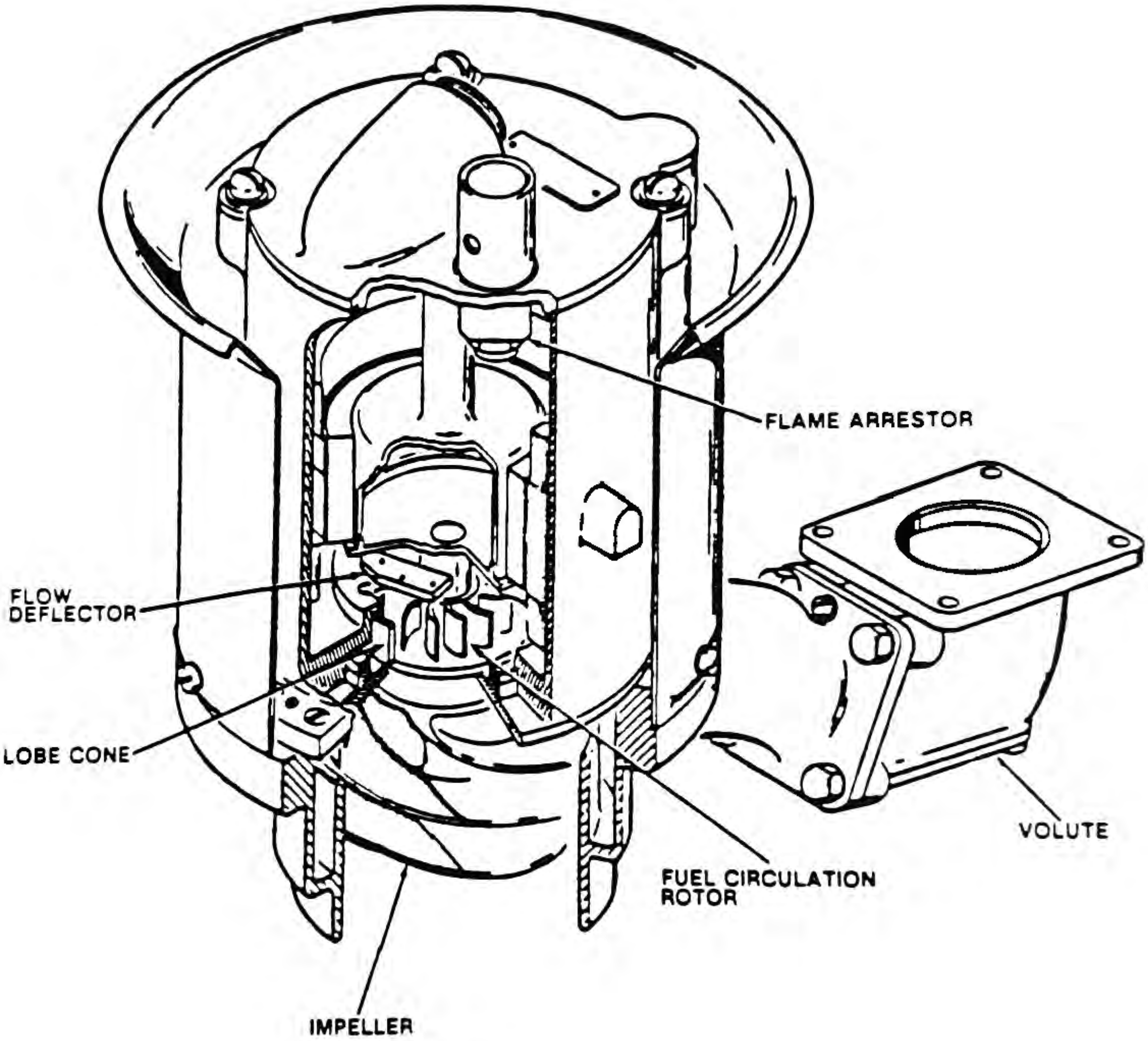
(1) Tank Fuel Boost Pump (See Figure 28-32)

(a) There is one fuel boost pump located in the reservoir of each main tank, one boost pump in the inboard end of each alternate tank, and two boost pumps located in the No. 3 main tank which pick up fuel through lines connected to the center tank. Each pump consists basically of a motor and impeller assembly. The pump is locked into position inside the volute by two locking lugs at the base of the pump housing. The boost pump is controlled through a switch on the flight engineer's control panel. The inlet port in the main tank boost pump volute picks up fuel directly from the reservoir. The outlet port discharges the fuel into the system piping. The inlet port of the outboard alternate tank boost pump volute picks up fuel directly from the tank (the center tank volute uses a pick-up line). The outlet port discharges the fuel into the system piping.

(b) The pump may be removed from the volute by using a special tool, if the fuel level is below the access door. All pumps are reached through access doors in the top of the wing, directly above the pumps.

(c) The pump has two lugs halfway down the housing, provided for use with the removal and installation tool. The impeller is enclosed in a cover that screws into the bottom of the motor housing. The upper portion of the cover is slotted to allow fuel to flow out of the impeller into the volute. The pump is the same in all tanks and consists basically of an armature shaft, motor field windings, lobe cone, fuel circulation rotor, impeller, and temperature limit switch. The temperature limit switch in the motor housing opens the electrical power circuit to the motor if the motor overheats. If the motor overheats, it must be replaced. Fuel is circulated through the motor for cooling purposes.

(d) The volute used in each main tank and each outboard alternate tank consists of a guide and a housing assembly with two locking pins and a spring-loaded flapper valve. The volute guide receives and mounts the motor and impeller assembly. The locking lugs on the motor housing are turned against the stops in the volute



TANK FUEL BOOST PUMPS

FTX80746

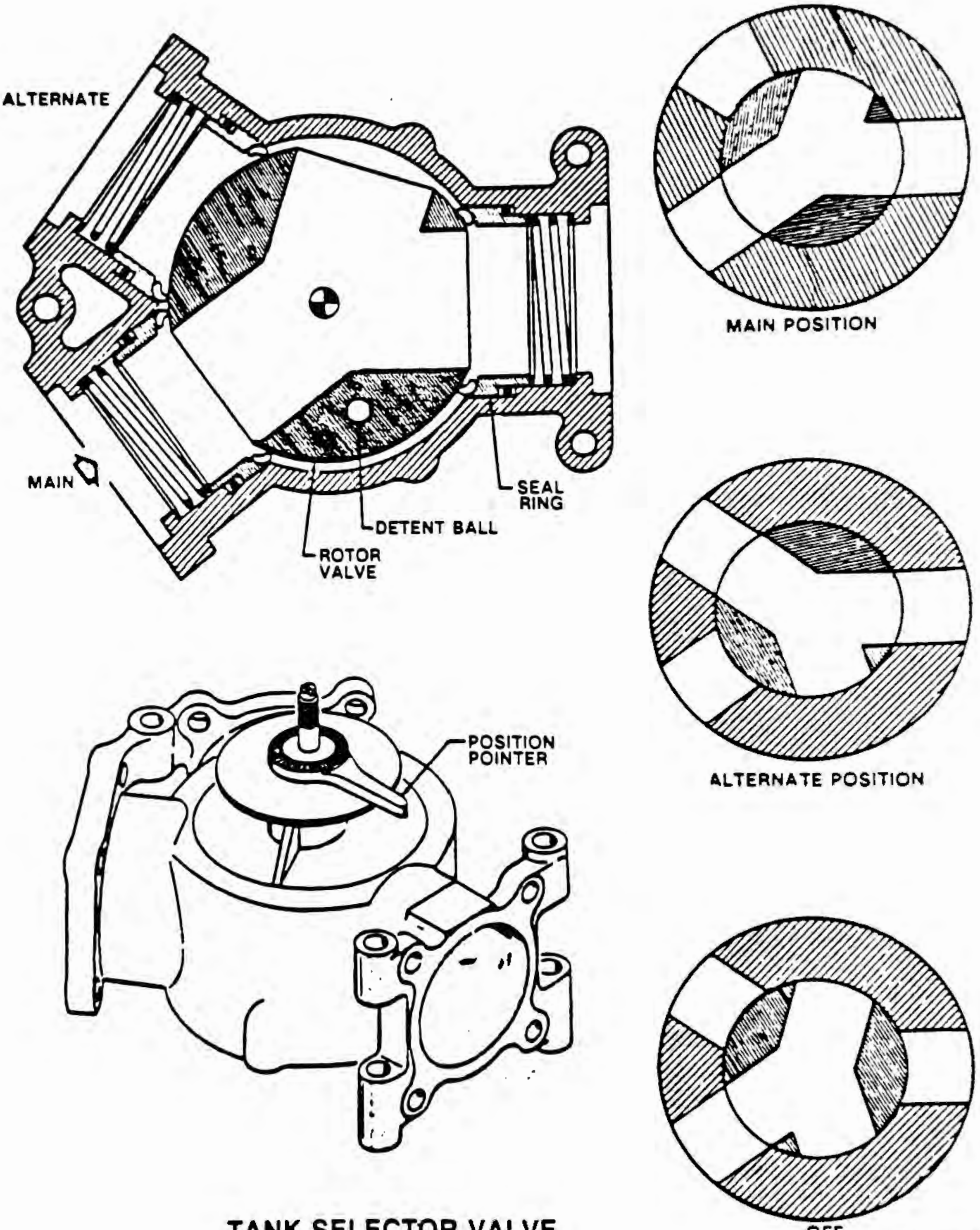
Figure 28-32

housing until the locking pins snap into locking position. In this manner, the locking lugs are held under the volute housing flange. The fuel enters the inlet port on the bottom of the volute housing and is discharged by the impeller through the flapper valve into the fuel system. The volutes used in the remaining tanks have the same type of motor guide and housing assembly as the other tank volutes but have flanged inlet ports that connect to remote pick-up lines. There are two spring-loaded flapper valves in the volute housing. As long as the pump functions, the normal outlet flapper valve is opened by the pump output pressure and the bypass valve remains closed. If the pump fails, the first valve will close and the bypass valve will open due to the engine-mounted boost pump suction.

(2) Tank Selector Valve (See Figure 28-33)

(a) The main and alternate tank selector valve is a 3-port cable-operated valve. The valve can be positioned to route fuel either from a main or alternate tank directly to its respective engine. It also can be positioned to shut off all fuel supply from the respective main and alternate tanks. The valve consists of a housing, a 3-port rotor valve assembly, a spring-loaded seal ring in each of the three housing ports, and a detent plate.

(b) The spring-loaded seal rings in the housing ports are held in constant contact to the valve rotor. As the valve is rotated to a detent position where one or two of the valve ports align with the ports in the housing, the seal rings seat and seal the mating ports. Two of the positions of the selector valve align either one of the inlets with the outlet port. In either of these positions, the pointer of the coupling indicates which inlet is open to the outlet. The other position closes off both inlets to the valve outlet and is indicated by the position of the pointer between the outlet and one of the inlet ports. The center wing tank selector valve and the forward auxiliary tank selector valve are manually operated gate type valves. The center tank valve is identical to the crossfeed valve. The forward auxiliary tank valve is similar in construction and operation.



TANK SELECTOR VALVE

Figure 28-33

(3) Crossfeed Valve (See Figure 28-34)

(a) The crossfeed valve is a manually operated gate-type valve. The valve is installed between the engine fuel supply line and the crossfeed manifold, just downstream of the tank selector valve.

(b) The valve assembly consists of a slotted blade, valve arm assembly, and valve shaft. The blade is slotted for the mating roller of the arm to work in. The roller moves on a shaft that is secured to the valve arm. The arm moves with the shaft as it is rotated. The valve shaft rotates 90 degrees from the open to the closed position of the blade. The blade is normally seated (closed) between two spring-loaded ring seals. When the blade is pulled into the upper portion of the housing, the valve opens and allows fuel to enter or leave the crossfeed manifold.

(c) The valve has a short connecting drive shaft between the operating cable bellcrank and the valve shaft. This drive shaft assembly has a universal coupling that mates to the valve seated drum. The valve drum has a pin-indicator to relate valve position to a reference plate placarded OPEN and CLOSED.

(d) A line thermal relief valve and a body thermal relief valve relieve excessive pressure buildups due to the expansion of tapped fuel. The line relief valve opens at 22 to 32 psi to bleed pressure from the engine supply line around the normally closed blade into the crossfeed manifold.

(c) With the flapper normally seated and static fuel trapped in the down-stream piping, excessive pressure could build up because of thermal expansion of the fuel. At 60 (±5) psi, the thermal relief valve opens and relieves the pressure. The cracking pressure of the fuel transfer line valves is 2.0 (+0.2, -0) psi. The cracking pressure of the leading edge valves is 0.1 to 0.5 psi.

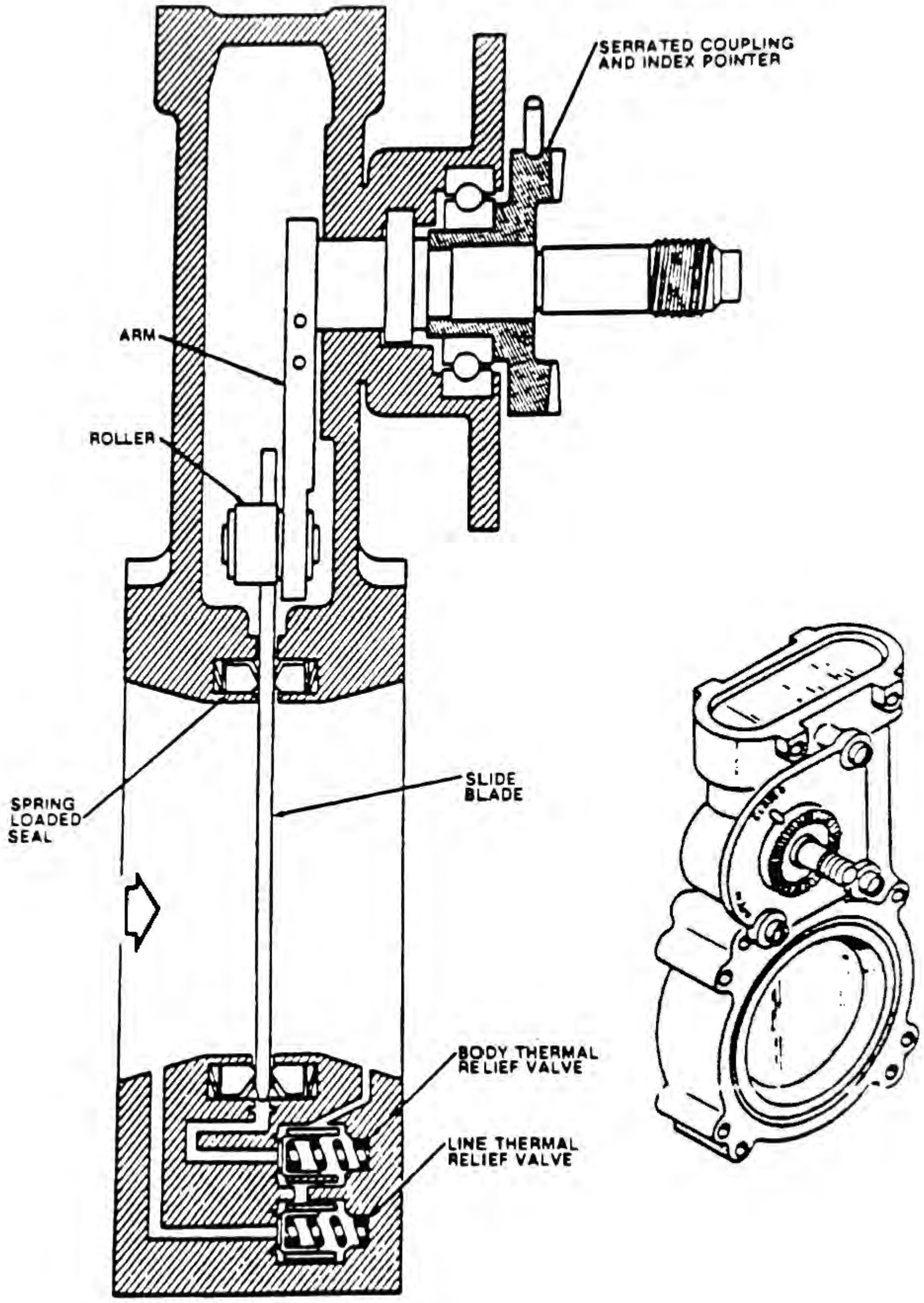
C. Operation

Fuel supply to engine with a corresponding main or alternate tank is accomplished by pumping fuel from the selected tank, through the tank selector valve and fire shutoff valve into the engine supply line to the engine. As the inboard main tank has no tank selector valve, fuel is pumped directly to the supply line through the fire shutoff valve. Pumping is accomplished by placing the boost pump switch in the boost and feed position (main tanks only) or the boost and feed position, the reservoir feed pump is also activated. The feed pump picks up fuel from the main portion of the main tank and feeds the fuel into the reservoir through the tank inlet selecting valve. When the engine is running, fuel will normally be drawn from the tank by the engine-driven fuel boost pump without the use of the tank boost pump. Fuel can be routed from one tank subsystem to any or all of the remaining subsystems by opening the crossfeed valves for the affected systems. Fuel from the forward auxiliary tank is routed through the forward auxiliary tank selector valve into the center wing tank. Fuel from the center wing tank is routed through the center wing tank selector valve into the crossfeed manifold.

8. Dump - Description and Operation

A. General (See Figures 28-38 and 28-39)

The fuel dump system provides a means of reducing the airplane gross weight to below the airplane maximum allowable landing gross weight while retaining adequate fuel reserves. Fuel dumping is accomplished through cable-operated dump valves and dump chutes. The system is operated electrically by means of the fuel dump switch, located on the right side of the overhead switch panel in the flight compartment. Power for the system is 115 vac supplied through a 5-ampere circuit breaker located on the fuel management and engine section of the electrical power center circuit breaker panel. The system may also be operated manually by means of a handcrank, which can be fitted to the actuator at the systems engineer's table. This crank is stowed on the right-hand side of the table.


SERRATED COUPLING AND INDEX POINTER
ARM
ROLLER
SPRING LOADED SEAL
SLIDE BLADE
BODY THERMAL RELIEF VALVE
LINE THERMAL RELIEF VALVE

CROSSFEED VALVE

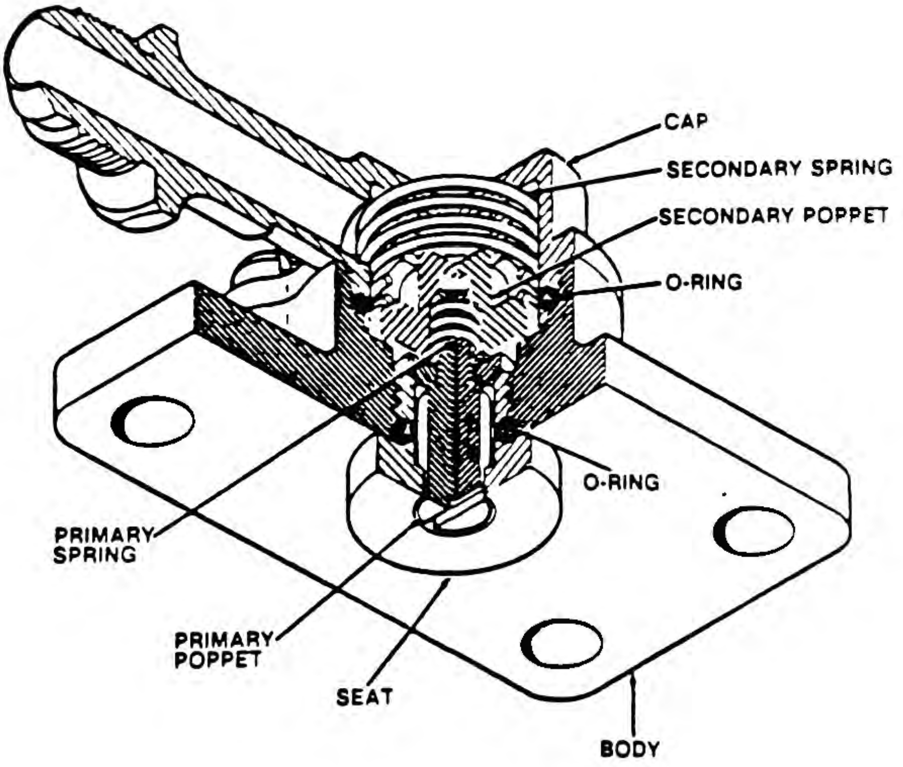
FTX80748

Figure 28-34

(4) Crossfeed Manifold Drain Valve (See Figure 28-35)

(a) The crossfeed manifold drain valves are manual, poppet type valves identical to the vent manifold drain valves. There is one valve located in the low point of the crossfeed manifold on each side of the fuselage in the lower surface of the wing leading edge.

(b) The manifold is drained by depressing the poppet to allow fuel to flow.



CROSSFEED MANIFOLD DRAIN VALVE FTX80749

Figure 28-35

(5) Engine Fuel Fire Shutoff Valve (See Figure 28-36)

(a) The engine fuel fire shutoff valve is a manually operated gate-type valve. There is one valve in each engine fuel supply line in the wing leading edge. The valve is operated by the respective fire control handle in the flight compartment.

(b) The valve consists of a valve arm, valve arm link, cam plate, and slide blade. The valve arm link attaches to the valve arm and is allowed to swivel through an arc in relation to the valve arm. The link has a stop that will contact the arm when the two have traveled to the valve closed full overtravel position. In the full open pretravel position. In the full open pretravel position, the link contacts the arm stop.

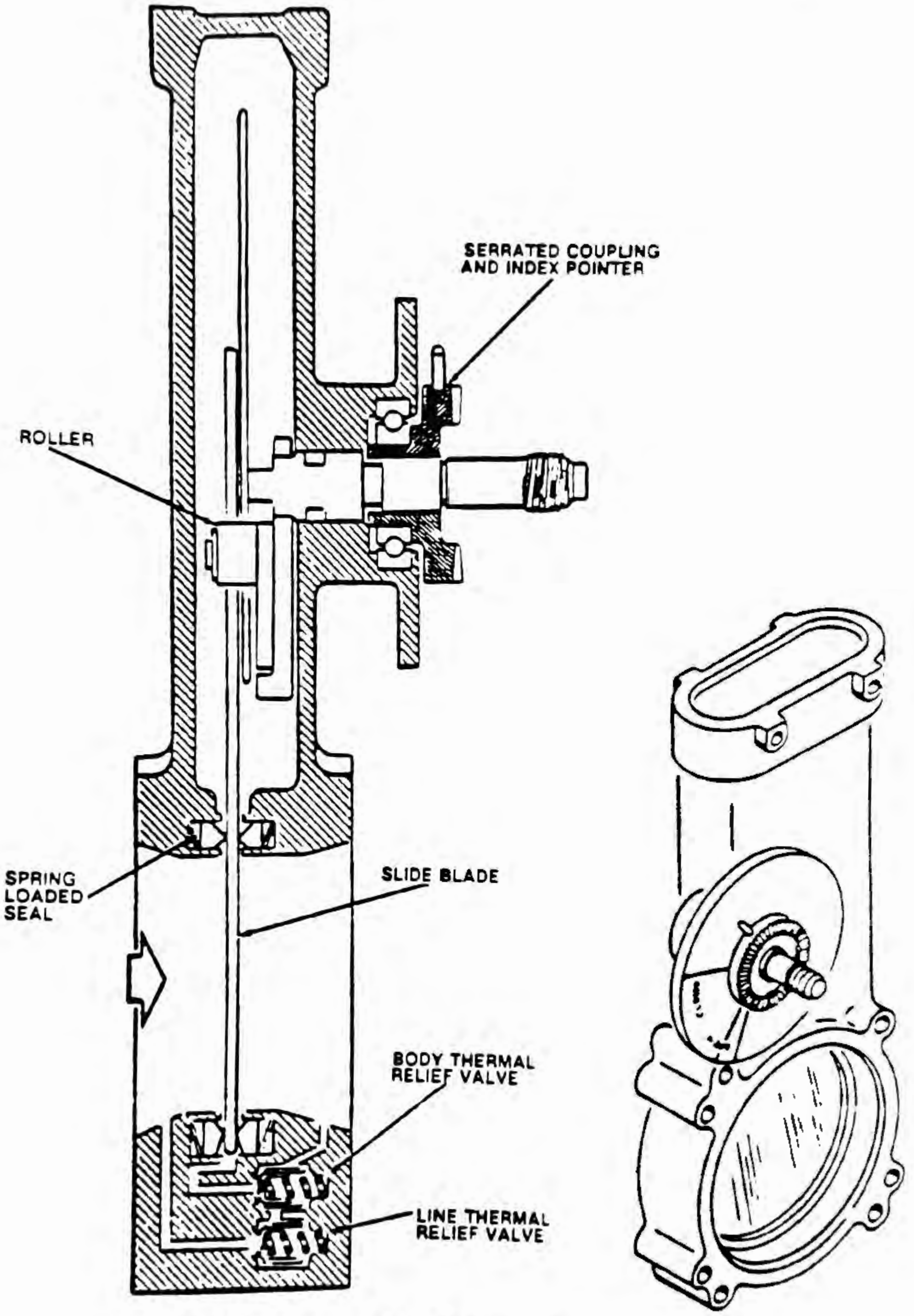
(c) A roller attached to the end of the link rides in, and extends through, a J-shaped slot in the cam plate. The rotation of the valve arm causes the link roller to follow the cam slot, allowing the arm and link to move through independent arcs.

(d) The slide blade (gate valve) is slotted near the one end and also receives the link roller extending through the cam slot. The slide blade is positioned parallel to the cam plate and is guided by two grooves in the housing. This will allow the blade to open or close through porting of the valve by the action of the arm and link. The cam plate is pinned to the valve shaft, securing it rigidly in two positioning grooves in the housing.

(e) The valve has a pin-indicator to relate valve position to a reference plate placarded OPEN and CLOSED.

(f) Two line thermal relief valves and a body thermal relief valve relieve excessive pressure buildups due to the thermal expansion of trapped fuel. The line relief valves open at 22 to 32 psi to bleed this pressure around the blade of the closed valve. The line relief valves are positioned to relieve in either direction.

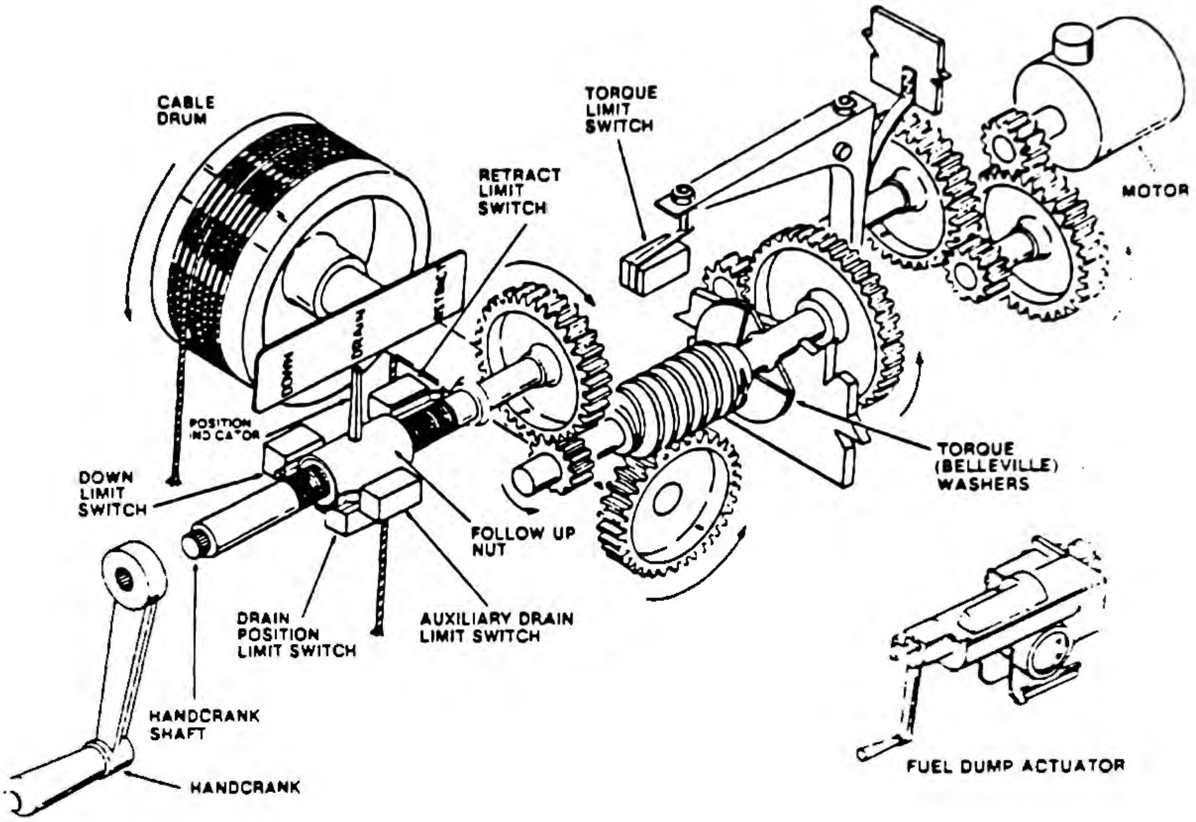
(g) The gate valve is normally open. In this position, the cable drum has rotated the valve arm up in the housing, pulling the link arm with it. This positions the link roller at the upper end of the cam "J" slot and holds the slide blade open (up). To shut off the


SERRATED COUPLING AND INDEX POINTER
ROLLER
SPRING LOADED SEAL
SLIDE BLADE
BODY THERMAL RELIEF VALVE
LINE THERMAL RELIEF VALVE

ENGINE FUEL FIRE SHUTOFF VALVE

FTX80750

Figure 28-36



FUEL DUMP ACTUATOR - SCHEMATIC

FTX80754

Figure 28-40

(b) The actuator is attached to the right side of the systems engineer's table and consists of an electric motor, reduction gears, lever arm and load limit switch, a drum and cable assembly, and position limit switches. An external handcrank is included for attachment to the handcrank shaft.

(c) The motor is a reversible, 115-vac, single-phase type with integral thermal protector. It operates through the reduction gearing of 821 to 1 to drive the drum and cable assembly.

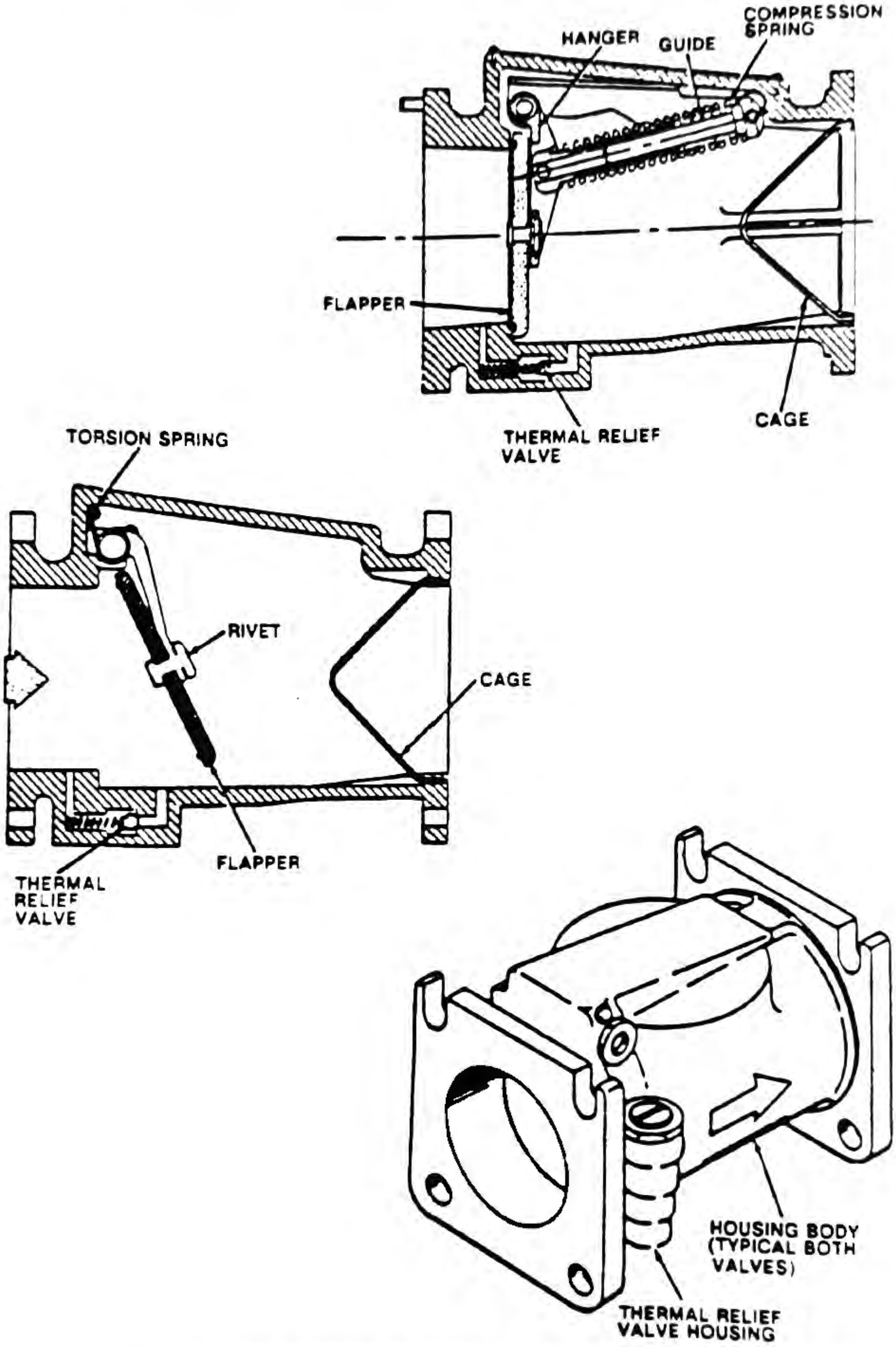
airplane fuel supply to the engine, the respective fire control handle in the flight compartment is pulled, causing the valve cable drum to rotate and start the valve closed. This rotates the valve arm and forces the attached link with roller to ride downward following the cam slot. The slide blade is also forced downward by the link roller but will not start entering the valve through porting until the arm has moved through 8 degrees of pretravel. The blade will continue down until it completely closes off all flow through the valve porting. At this point the arm has traveled through an arc of approximately 80 degrees and the arm movement has caused the link roller to ride around the bottom portion of the cam slot and up into the end of it. The arm will continue to travel another 69 degrees. This is due to the link roller only moving slightly up and down in the slot end as the arm continues around until the arm stop contacts the link stop heel.

(h) The valve overtravel will allow other shutoff valves in the same cable system to sequence closed. This operation would be reversed to open the valve.

(6) Line-Mounted Check Valves (See Figure 28-37)

(a) There are two types of line-mounted check valves. The valves are identical, except that the valves mounted in the fuel transfer lines between the outboard alternate and the outboard main fuel tanks have a heavier (compression-type) spring and an alignment pin. The valves in the fuel transfer lines from the outboard alternate tanks to the outboard main fuel tanks prevent an inadvertent transfer of fuel. The valves located on the wing leading edge have a light spring (torsion-type coil) and prevent the reverse flow of fuel.

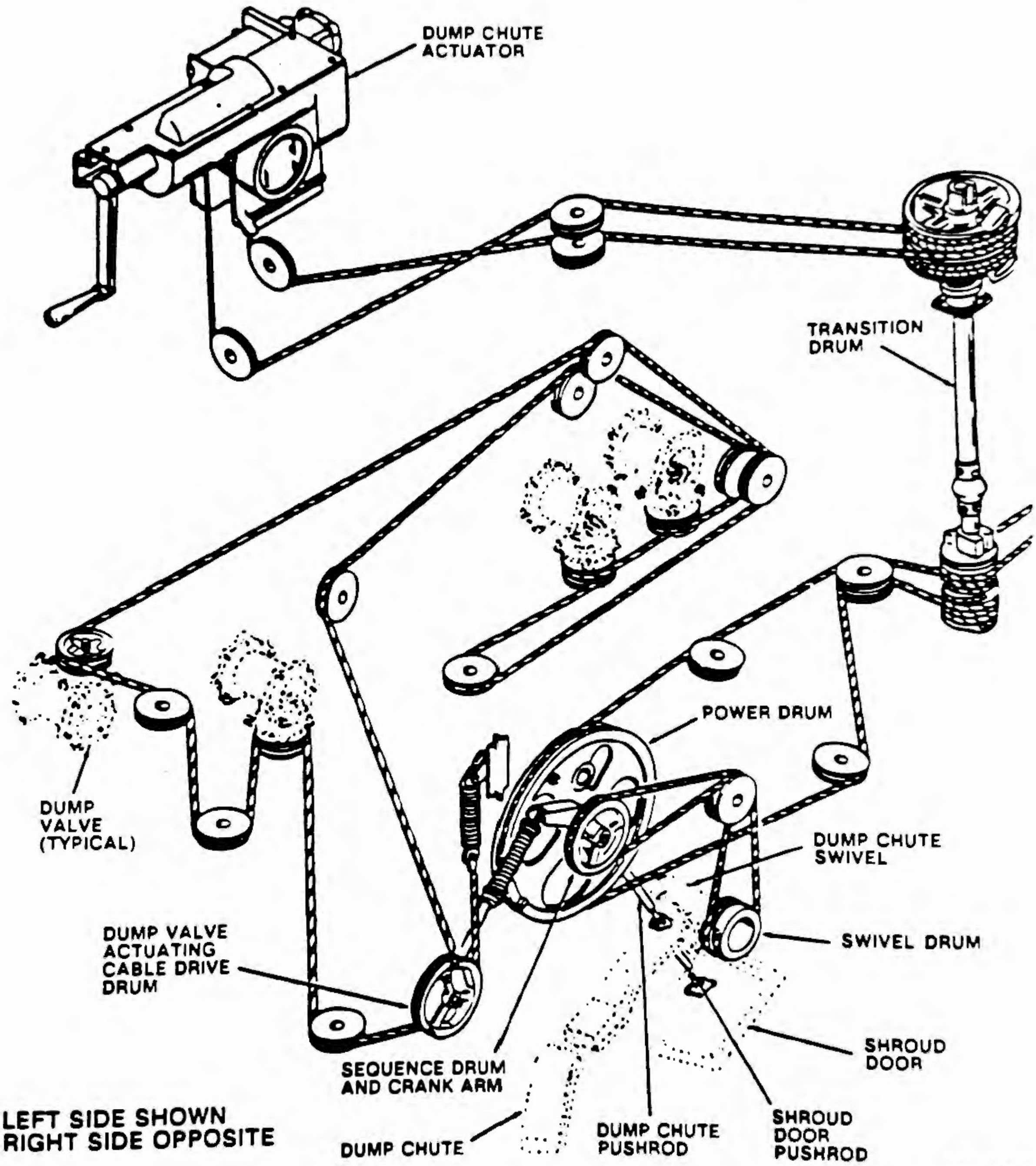
(b) Internally, both valves have a flapper, a thermal relief valve, a spring, and a cage. The flapper is spring-loaded closed and is self-aligning, with a bonded seal that seats against the internal inlet end of the valve housing. The valve housing is recessed, allowing the flapper to open and move out of the fuel flow path, thus permitting unrestricted fuel flow. The cage in the outlet port of the valve housing prevents the flapper from restricting fuel flow through the valve as the flapper becomes detached from the valve housing.



LINE MOUNTED CHECK VALVES

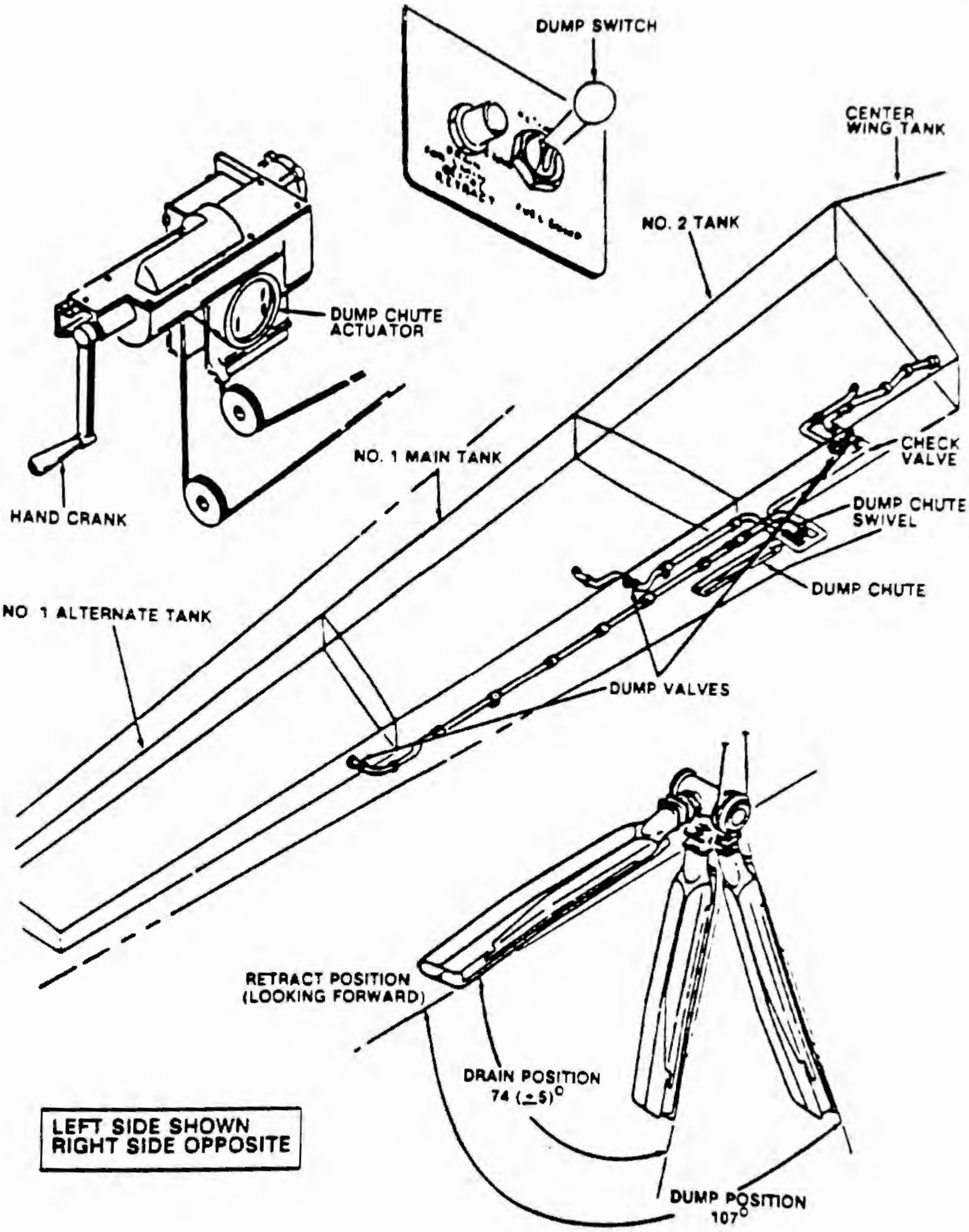
FTX80751

Figure 28-37



FUEL DUMP MECHANICAL CONTROLS - SCHEMATIC

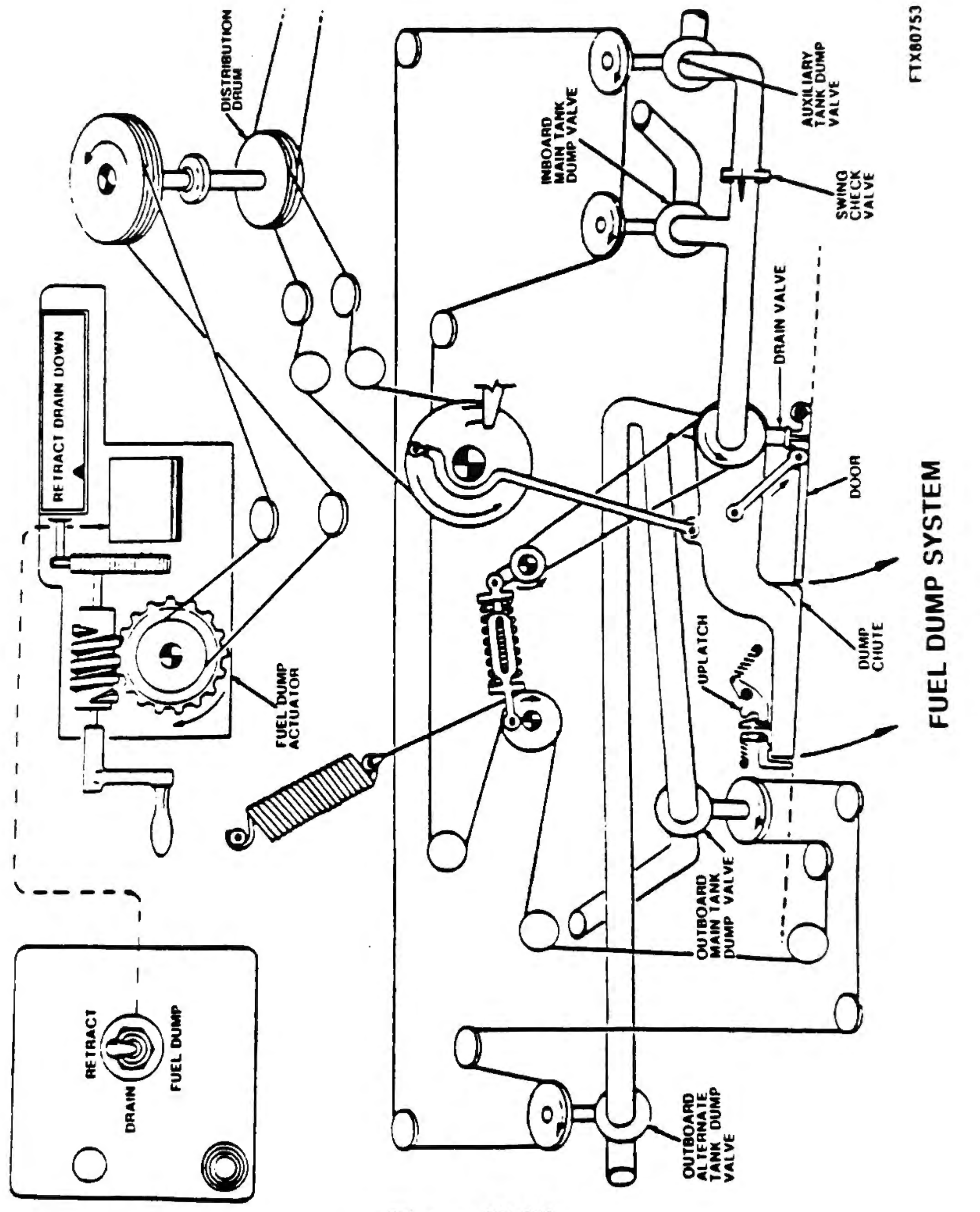
Figure 28-41



FUEL DUMP INSTALLATION

FTX80752

Figure 28-38



FUEL DUMP SYSTEM

Figure 28-39

The dump system is divided into similar left and right subsystems, one in each wing. Both subsystems are operated by a common actuator. The dump system consists basically of an actuator, mechanical controls, one dump valve per tank, a standpipe in each main tank, and one dump chute, with drain valve, for each subsystem. The dump chutes are located aft of the wing rear spar outboard of the main gear wheel wells. A shroud door is located at the inboard end of each dump chute to fair the chute with the wing. Standpipes in the main tanks are positioned to prevent dumping fuel below the required fuel reserve. This reserve will vary according to airplane attitude. Stops are provided for positive positioning of the chutes in the extended (dump) and retracted positions. Each dump chute has a drain valve to prevent accumulation of fuel or water in the chute while it is retracted. The drain valve is spring-loaded to the closed position and is opened by the dump chute door when the door is retracted. The chutes are connected to a common cable system for actuation. Each chute is also connected to a sequencing mechanism and cable system to actuate the corresponding dump valves. A latching mechanism near the tip of the chute will prevent the chute from free falling in the event of a system cable breaking or a malfunction, and the warning flag will be exposed 3/4 inch below the wing skin.

B. Description

(1) Fuel Dump Electrical Control Switch

(a) The fuel dump electrical control switch is located to the right and above the overhead switch panel. The switch is a 3-position toggle switch. The positions are placarded: RETRACT, DRAIN, and FUEL DUMP. The switch is lever locked in the retract position.

(b) The switch provides 115-vac power to the fuel dump chute actuator motor.

(2) Fuel Dump Actuator (See Figure 38-40)

(a) The fuel dump actuator is an electro-mechanical actuator that can be operated electrically or manually. The actuator supplies the working force required to operate the dump system's actuating mechanisms.

(d) The gear train consists primarily of a splined gearshaft with a spur gear and a worm gearshaft with the worm in the middle and a spur gear at each end. Two torque (Belleville) washers preload the worm gear train, providing the spring force required for the operation of the lever arm and load limit switch, in the event of a system over load during the retraction cycle.

(e) The four limit switches, operated by the followup nut on the handcrank shaft, are identified as extend, drain, auxiliary drain, and retract.

(f) A pointer, attached to the followup nut, is visible through an opening in the housing and indicates the relative position of the dump chutes.

(g) The handcrank is internally splined to mate to the external end of the handcrank shaft and can be detached from the unit for stowing.

(h) During electrical operation, the motor is energized and rotates the cable drum through the gear train. This winds the cable and causes the dump system to function and the chutes to extend or retract. Rotation continues until the followup nut actuates a limit switch and opens the circuit. If the actuator fails to stop the chutes at the drain position on the way up from the dump or full down, the auxiliary drain limit switch will open the circuit and stop them at the auxiliary drain position. The full retraction of the chute must then be obtained by manual operation.

(i) Operation of the load limit switch occurs when the torque on the gear train, resulting from high air loads on the chutes that tend to hold them from completely coming full up or travel beyond the retract limit, is sufficient to overcome the load of the torque washers and compress them. This permits the worn gearshift to push against the lever arm and actuate the load limit switch.

(j) The motor operation of the dump system will fully extend or retract the chutes in 50 (±20) seconds. The crank turns a total of 56.3 revolutions to run the chutes through full travel.

(3) Fuel Dump Mechanical Controls (See Figure 28-41)

(a) The fuel dump mechanical controls are cable runs, directed from the systems engineer's panel, through the lower fuselage by a series of pulleys to a transition drum. From the transition drum, cables extend into each wing trailing edge to a large power drum. The left and right systems are identical; therefore, only one will be described in detail.

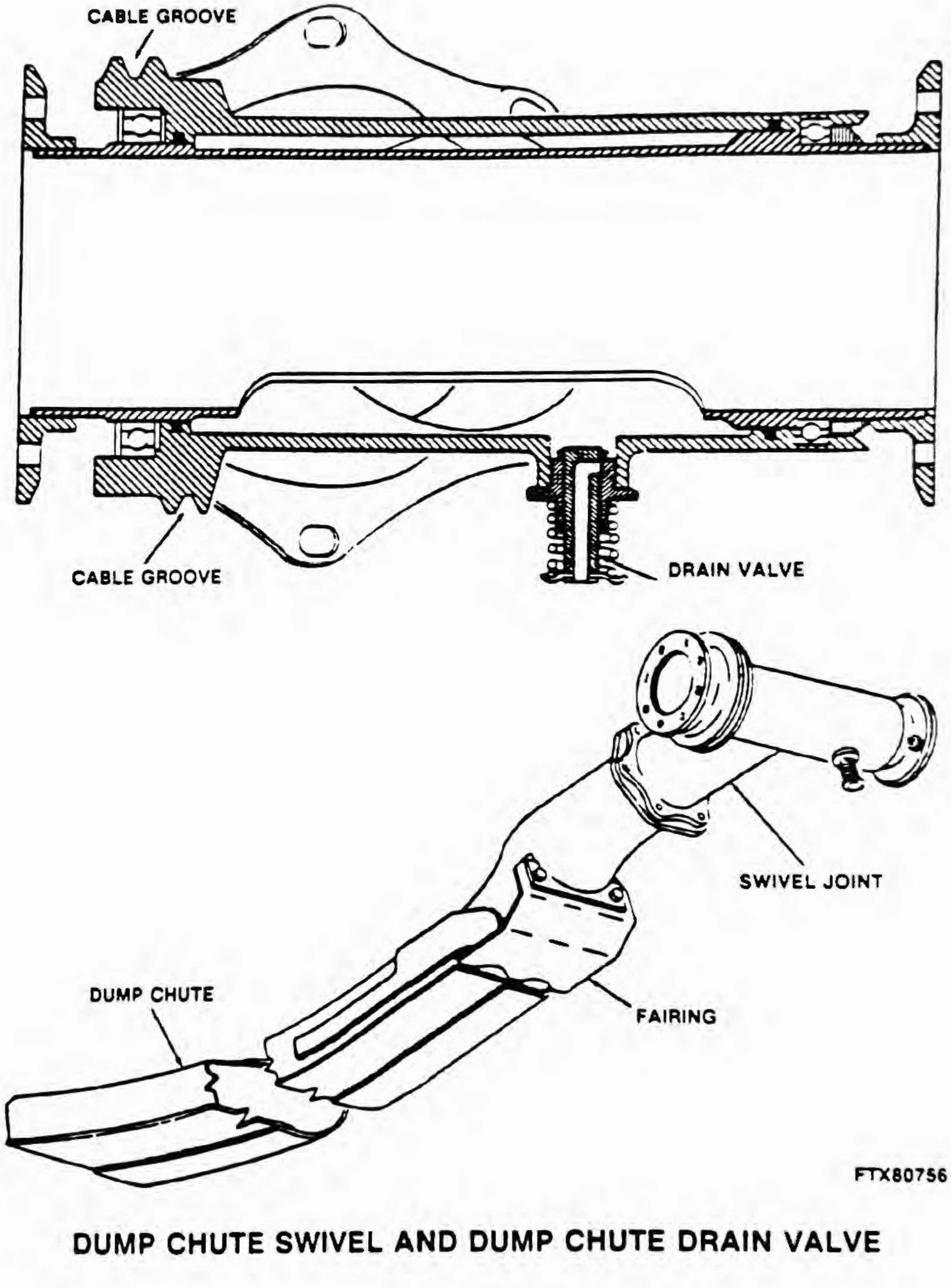
(b) The transition drum consists of two cable drums attached to either end of a shaft, located just aft of the rear spar in the center wing. The shaft runs through a pressure sealed panel between the pressurized and nonpressurized areas. The upper drum is driven by the fuel dump actuator and drives the lower drum that operates the cable runs out into the wing to the power drum.

(c) The power drum has an independently operated sequence drum with a crank arm, riding on two sets of bearings to a common center shaft. The arm has two lugs with a through pin at the end. This pin rides in a slotted link rod against spring tension. The rod attaches at the other end to the dump valve actuating drum.

(d) Two cable runs go to the the four dump valve cable drums. A large spring, with attached cable to the actuating drum, aids in closing the dump valves when the chute is returning to the full up position. A rigid pushrod attaches to the outer diameter of the power drum and connects to the dump chute for the push-pull operation of the chute. Also, attached to the chute, is a short pushrod, connected to the dump chute shroud door to sequence it with the chute operation. The dump chute swivel joint has an integral drum with a cable run to operate the sequence drum crank arm.

(4) Dump Chute Swivel (See Figure 28-42)

The dump chute swivel connects the fuel dump manifold to the dump chute. The swivel allows the dump chute to hinge at its inboard end, so that the dump chute can be retracted to the faired position with the lower wing skin, or may be extended to the fuel dumping position.



DUMP CHUTE SWIVEL AND DUMP CHUTE DRAIN VALVE

Figure 28-42

is compressed to the open position. This provides a means of draining the chute of any water or fuel that might enter the system while the chutes are in the retract position.

9. Indicating - Description and Operation

A. Description

The indicating systems include fuel quantity, fuel low-level indicating light, reservoir feed pump pressure, and tank fuel temperature systems. The fuel quantity system provides both a capacitance-type indicating system and manual measuring sticks to measure fuel quantity. The fuel low-level indicating light system provides a means of monitoring the fuel level in the No. 1 and No. 4 alternate tanks during flight. The reservoir feed pump pressure system provides an indication of the pressure differential across the feed pumps in the main tank reservoirs. The tank fuel temperature system indicates the fuel temperature in the No. 4 main tank.

B. Operation

Operation of each system is covered in individual sections of this manual.

10. Fuel Quantity Indicating System - Description and Operation

A. General (See Figures 28-45 and 28-46)

(1) There are two method of indicating fuel quantity in the airplane fuel tanks. First is the fuel quantity indicator located in the flight compartment, which, together with fuel quantity probes located in the fuel tanks make up the true-weight fuel quantity indicating system for each tank. A total fuel quantity indicator (totalizer) is also located in the flight compartment and is utilized to indicate the total fuel quantity (weight) in all the tanks. The second method of indicating the tank fuel level is by magnetic measuring sticks, installed in the tank bottom skin, which measure fuel depth. They are used as an alternate method of fuel measurement and to verify the indicated fuel quantity when airplane is on the ground.

(2) The fuel quantity indicating system operates from a self-balancing capacitor bridge circuit. The primary sensing elements of the bridge circuit are the tank units, which are capacitor probes. A compensator incorporated in the lower end of one probe in each tank is connected

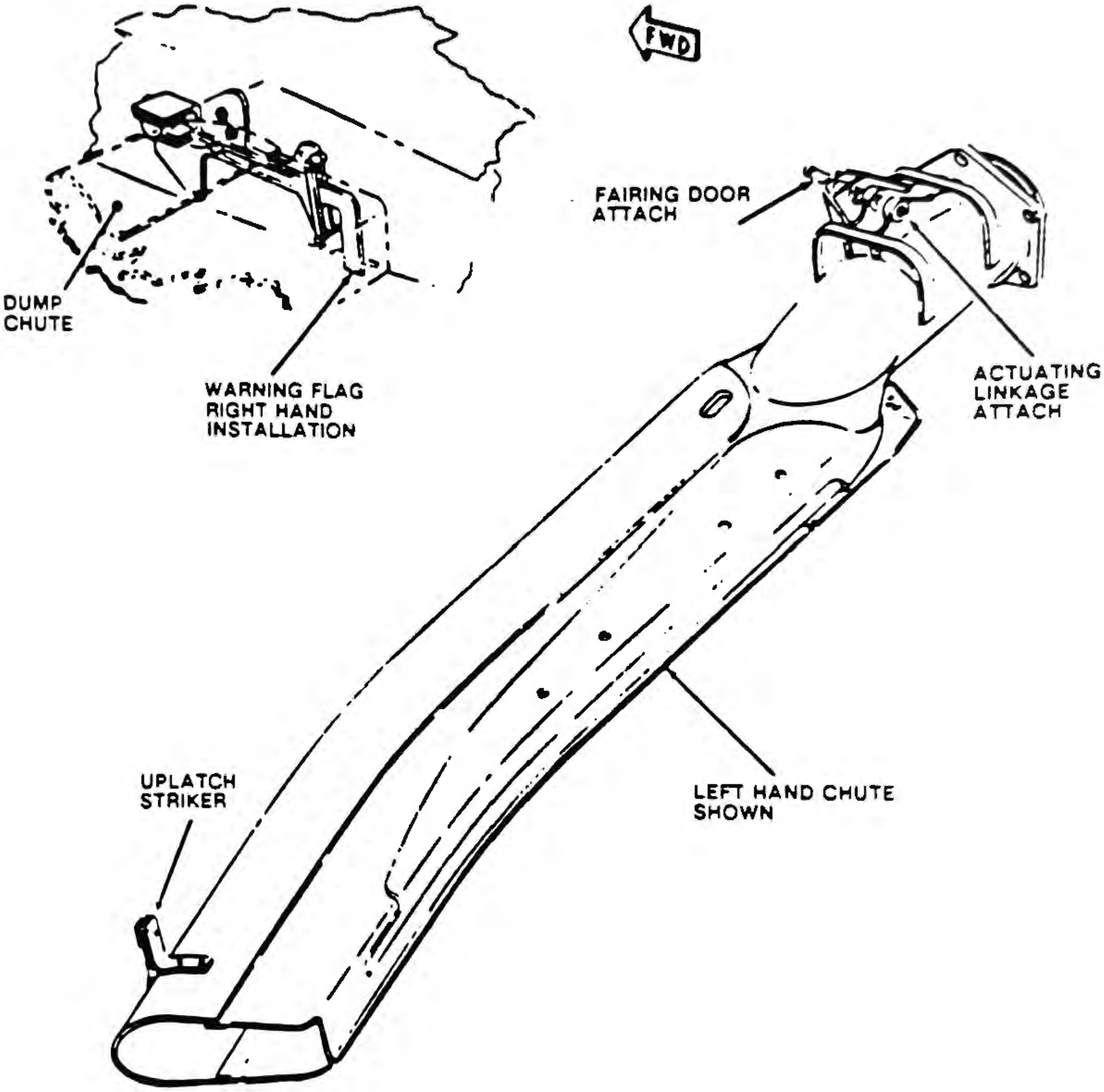
(5) Fuel Dump Chute (See Figure 28-43)

(a) There are two dump chutes, located aft of the rear spar, outboard of each main gear wheel well. The dump chutes are stowed approximately parallel to the rear spar, and flush with the lower wing skin. The dump chutes are attached to the fuel dump manifold by the swivel, which allows the dump chutes to pivot downward to the fuel dumping position. Tapered spacers are provided between the chute and the swivel to enable the chute to be faired with the shroud.

(b) The dump chute door is hinged to the lower wing skin at the outboard end of the dump chute shroud, and is connected to the dump chute by the actuating linkage. When the dump chute is in the retracted position, the door fairs with the shroud.

(c) The dump chute uplatch striker is located at the outboard, forward side of the dump chute. The striker engages the dump chute uplatch located in the outboard, forward side of the shroud, when the dump chute is in the retracted position.

(d) The dump chute uplatch warning flag, located at the outboard end of the shroud, provides a visual indication when the dump chute is not fully retracted. The flag is operated automatically by the dump chute. The flag protrudes approximately 3/4 inch from the lower wing skin whenever the dump chute is hanging on the uplatch, and is flush when the dump chute is fully retracted.



FUEL DUMP CHUTE - SCHEMATIC

FTX80757

Figure 28-43

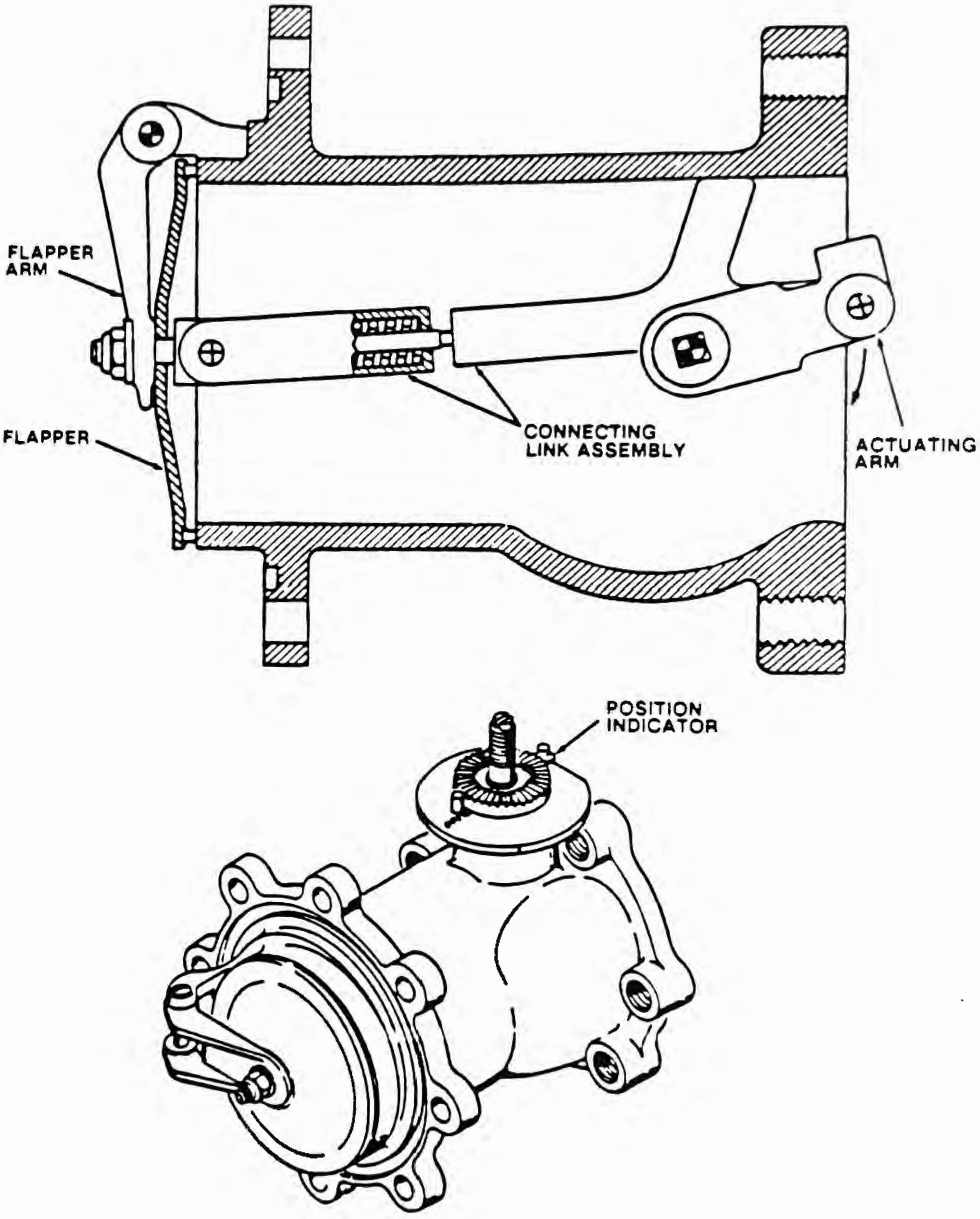
(6) Fuel Dump Valve (See Figure 28-44)

(a) The fuel dump valve is a normally closed, cable-operated, flapper-type valve. There is one valve for each fuel tank.

(b) A valve position indicator relates the valve position to the housing, placarded OPEN and CLOSED. A connecting link is bolted between the forked end of the actuating arm and the valve flapper. The link assembly incorporates a stop and spring to provide for position valve closure. The spring keeps the valve seal preloaded when the actuating arm is moved over center against the stop. The stop facilitates valve rigging. The flapper bolt extends through the flapper and the attaching flapper arm. The arm is hinged from two lugs on one side of the inlet housing by a clevis bolt. All bolt-attached hinging points are shimmed and bushed to offer minimum resistance to valve operation.

(c) The circular flapper is self-aligning with the housing seat and has a bonded seal on its mating inner face. The flapper has only two positions, open and closed.

(d) The valve is operated through the action of the mechanical control system on the valve cable drum. This rotates the valve shaft arm with the attaching link past the overcenter or locked closed position, causing the flapper to be pushed fully open and allowing the respective tank to dump fuel. When the flapper is closed, it is overcenter locked with sufficient seating force to prevent any fuel from leaking past the seal.



FUEL DUMP VALVE - SCHEMATIC

FTX80758

Figure 28-44

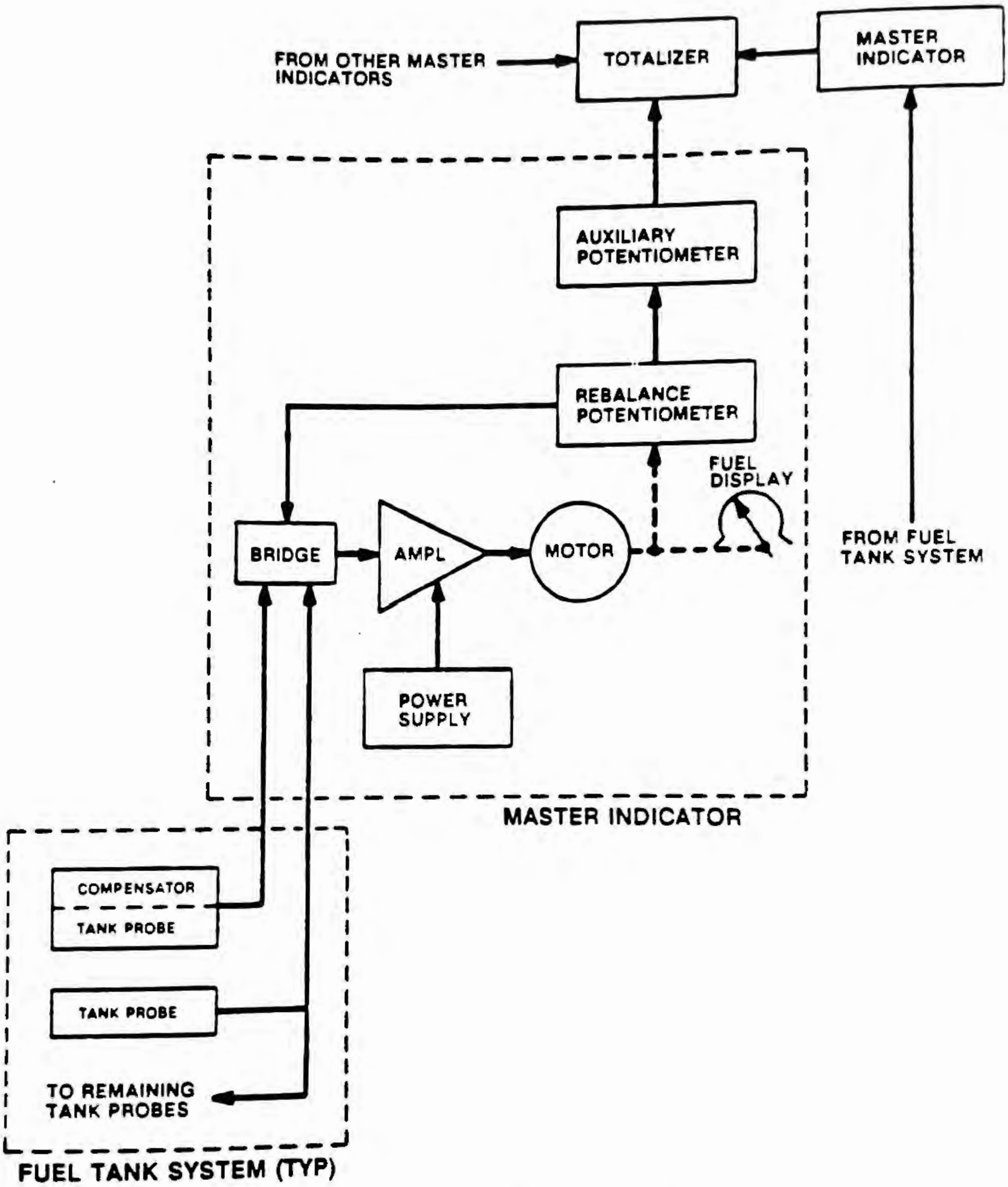
(7) Dump Chute Drain Valve (See Figure 28-42)

The dump chute drain valve, located on the lower side of the swivel, provides a means to drain condensation from the dump chute and the manifold. The drain valve is operated to the open position by the dump chute shroud door when the dump chute is retracted. The drain valve is spring-loaded closed when the dump chute is in the extended position.

C. Operation

(1) When the fuel dump switch is placed in the dump position, power is supplied through the switch to operate the dump chute actuator motor. The motor operates the dump actuator, moving the actuator cable drum. The cable drum, through cables and transition drums operates the power drums in the wings. The power drums, through pushrods, move the dump chutes to the dump position. As each chute starts downward, the swivel joints, through cables, rotate the sequence drum counterclockwise, causing the crank arm to compress the link rod spring and keep the dump valve actuating drum from moving off the valve closed stop. The short pushrod between the dump chute and the shroud door also moves the door to open as the chute lowers. As the chute nears the dump position, the sequence drum crank has rotated to a position that relieves the link rod spring tension and now commences to rotate the dump valve actuating drum. The actuating drum, through cables, now opens the dump valves, permitting fuel to be dumped. The clockwise rotation of the dump valve actuating drum also increases tension on the large return spring. This increases the returning power of the spring.

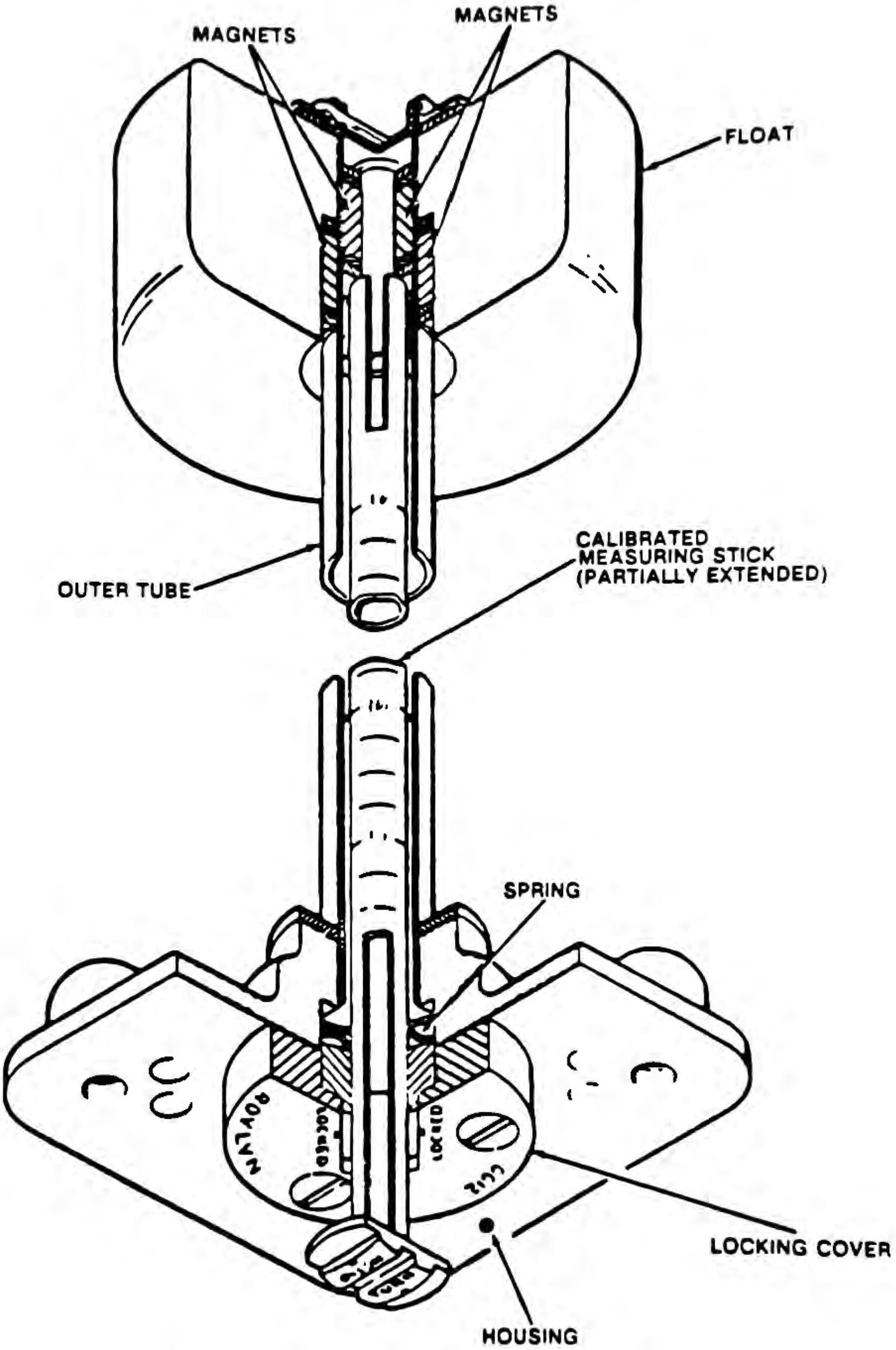
(2) After dumping is completed, the dump chute control switch is placed in the drain position. The actuator then rotates, moving the dump chutes to the drain position and closing the dump valves. The dump chutes are allowed to remain in the drain position until all residual fuel in the dump system has been drained. The switch is then placed in the retract position. The actuator rotates, moving the dump chutes to the fully retracted position. As the dump chute shroud door, actuated by the dump chute, nears the faired position, it contacts the dump chute drain valve. When the door has fully retracted, the valve



FUEL QUANTITY INDICATING SYSTEM - FUNCTIONAL SCHEMATIC

FTX80759

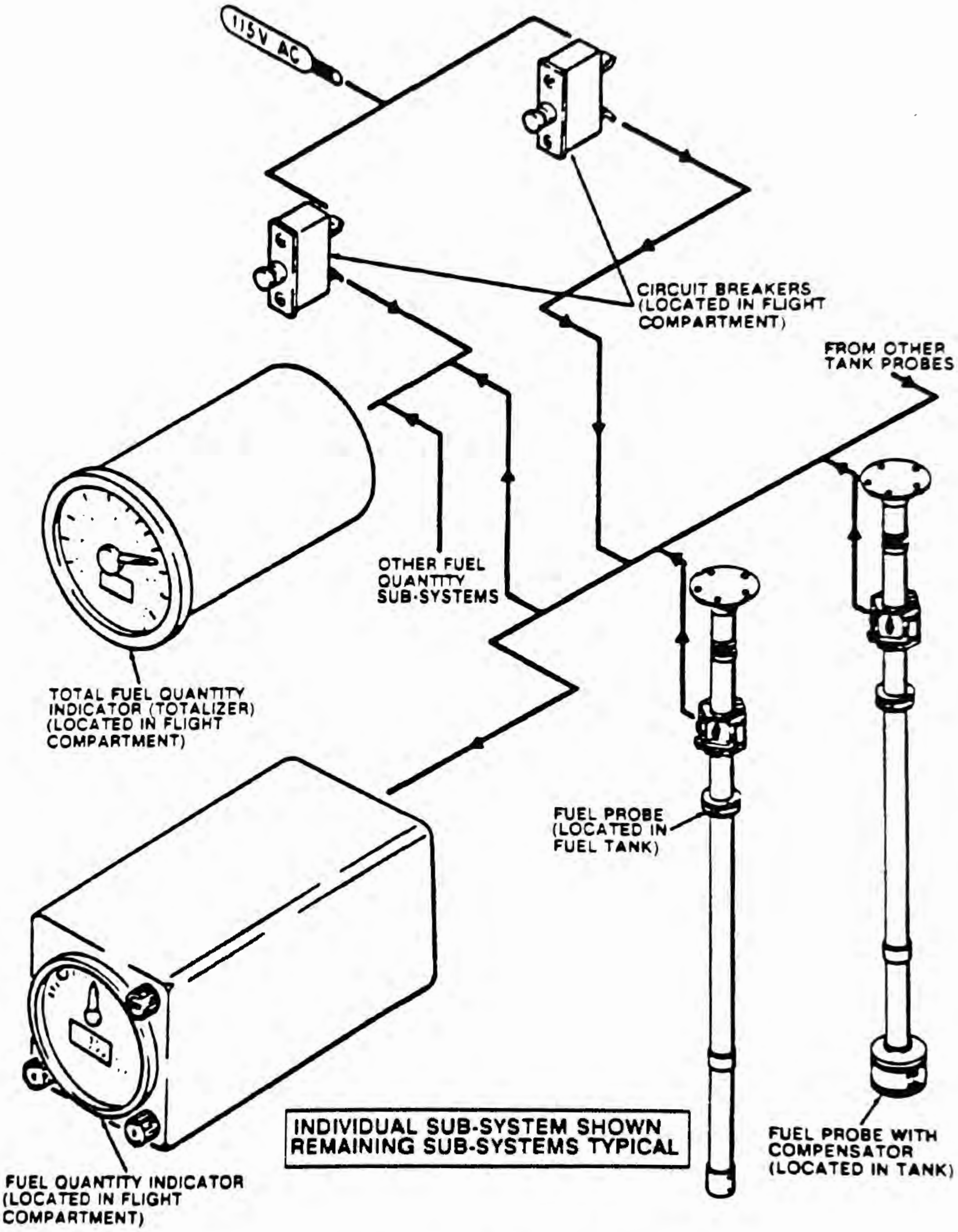
Figure 28-45



MAGNETIC FUEL MEASURING STICK

FTX80762

Figure 28-48


115V AC
CIRCUIT BREAKERS (LOCATED IN FLIGHT COMPARTMENT)
FROM OTHER TANK PROBES
OTHER FUEL QUANTITY SUB-SYSTEMS
TOTAL FUEL QUANTITY INDICATOR (TOTALIZER) (LOCATED IN FLIGHT COMPARTMENT)
FUEL PROBE (LOCATED IN FUEL TANK)
INDIVIDUAL SUB-SYSTEM SHOWN REMAINING SUB-SYSTEMS TYPICAL
FUEL PROBE WITH COMPENSATOR (LOCATED IN TANK)
FUEL QUANTITY INDICATOR (LOCATED IN FLIGHT COMPARTMENT)

FUEL QUANTITY INDICATING SYSTEM

FTX80760

Figure 28-46

into the bridge circuit to detect variations in the fuel dielectric constant. Information from the tank units and the compensator is combined to measure the quantity of fuel in the tank.

B. Description

(1) Fuel Quantity Indicator

(a) There is one fuel quantity indicator for each fuel tank. These units are combination indicator amplifiers and are located on the systems engineer's fuel control panel in the flight compartment. Each indicator has a calibrated dial, and a digital counter display indicating the true weight of the fuel in the corresponding tank.

(b) An electrical receptacle, coaxial connection, full adjustment, and empty adjustment are located on the back of the indicator. The indicators are supplied 115-volt AC power through circuit breakers located on the fuel management and engine section of the EPC circuit breaker panel. If the system power fails; the indicator pointer tends to stay at the last indicated position.

(c) Any difference between the amount of fuel in the tank and the amount shown on the indicator is sensed by the bridge circuit. This difference is amplified and controls an indication motor in the indicator which drives the indicator pointer to the correct indication. The motor also drives a totalizer potentiometer, which supplies quantity information to the totalizer indicator, and two balancing potentiometers to rebalance the bridge.

(d) On the front of the indicator is a pushbutton and a set knob. The pushbutton tests the indicator operation and, when pressed, the indicator pointer moves down towards zero. When the button is released, the pointer returns to its former indication. The set knob positions a fuel quantity selector point (bug) that travels the periphery of the indicator dial and an internal set switch cam. The cam causes the set switch to close when, during refueling, the indicated fuel quantity becomes the same as that of the selected fuel quantity. The switch directs 28-VDC power to the corresponding tank fill valve motor, closing the valve. When selecting the desired fuel quantity, the selector pointer should be positioned by the set knob to a setting below the indicated fuel quantity level and then moved to the desired fuel quantity setting above the indicated fuel level.

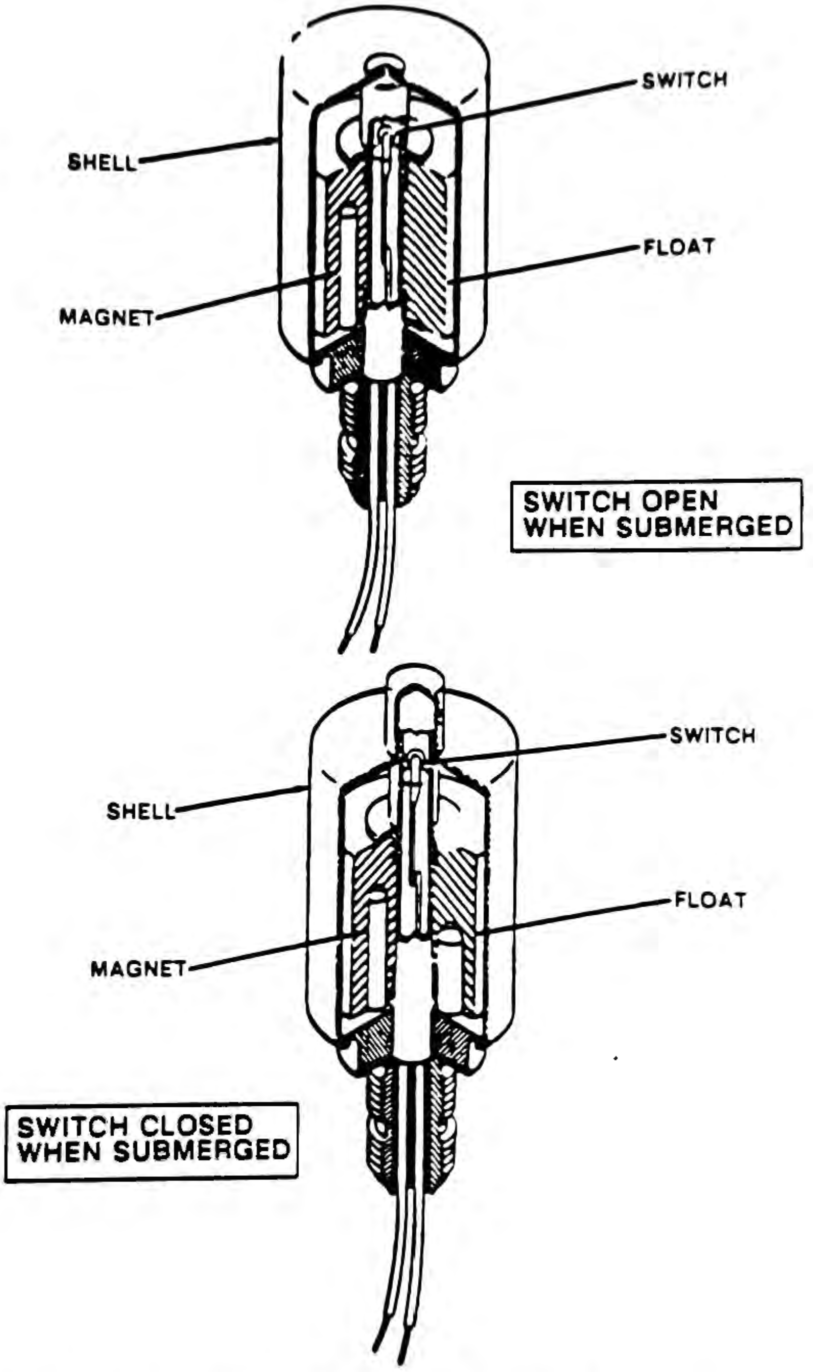
(2) Total Fuel Quantity Indicator

(a) There is one total fuel quantity indicator for the fuel quantity indicating system. The indicator is a combination indicator-amplifier. The indicator indicates the total weight of the fuel. An electrical receptacle and adjustments are located on the back of the indicator. Power to the indicator is supplied from the 115-volt AC bus through a circuit breaker.

(b) Fuel quantity information is supplied to the total fuel quantity indicator from each of the fuel quantity indicators. This information is totaled in a resistance summing network and balanced against the output of a motor-driven potentiometer within the total fuel quantity indicator. As fuel is added or used, the signals from the totalizer potentiometers in each fuel quantity indicator and the motor driven potentiometer in the total fuel quantity indicator are unbalanced. The resultant signal is applied to the amplifier which drives the motor and corresponding potentiometer until the signals are again balanced.

(3) Fuel Quantity Probes (See Figure 28-47)

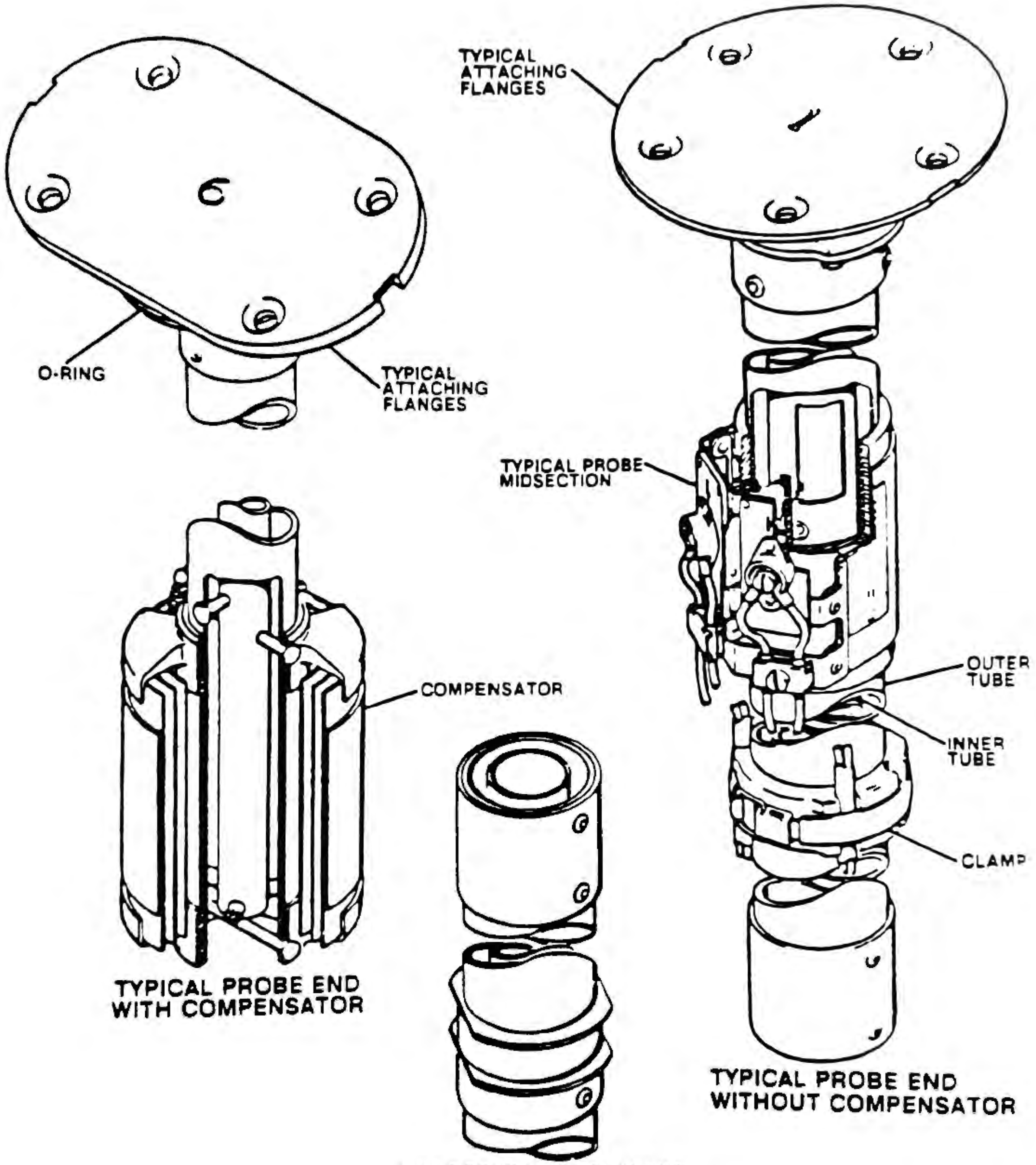
The fuel quantity probes consist basically of two concentric metal tubes which act as plates of an elector-static capacitor. All probes except the two aft probes in the center wing tank, are flange-mounted in the top of the tank (wing skin). The two aft probes are held in place within the tank by means of attaching clamps. All probes are interchangeable with their opposite counterparts. One probe in each tank (two in the center wing), has a compensator incorporated in the lower end of the probe. The function of the compensator in the fuel quantity indicating system is to compensate for variations in the fuel dielectric constant that can induce errors in the indicated fuel quantity of the tank. When the compensator is submerged in fuel it serves in the electrical circuit to nullify a change in the fuel dielectric constant.



FUEL LOW LEVEL INDICATING LIGHT FLOAT SWITCHES

FTX60764

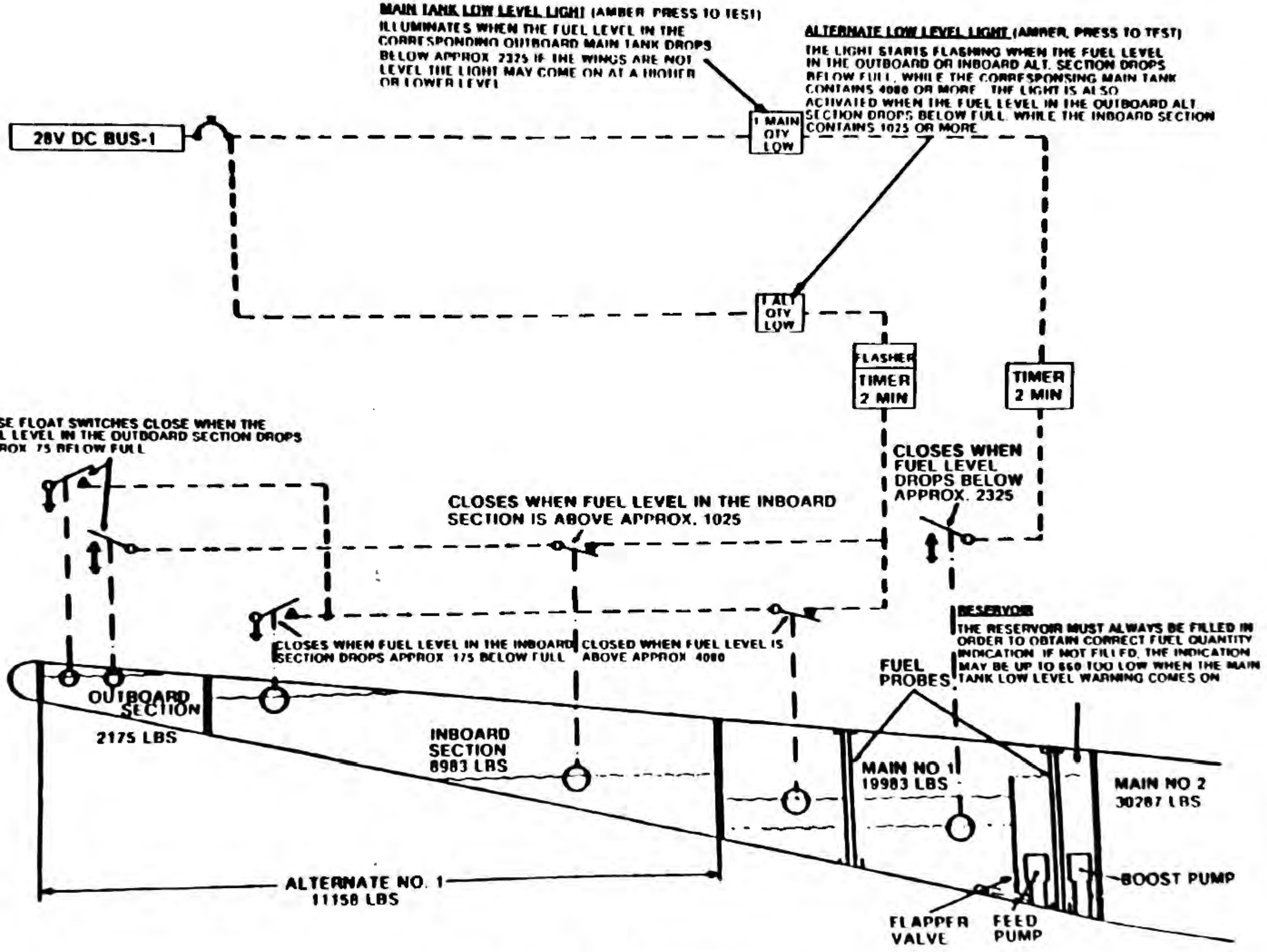
Figure 28-50


TYPICAL ATTACHING FLANGES
O-RING
TYPICAL ATTACHING FLANGES
TYPICAL PROBE MIDSECTION
COMPENSATOR
OUTER TUBE
INNER TUBE
CLAMP
TYPICAL PROBE END WITH COMPENSATOR
TYPICAL PROBE END WITHOUT COMPENSATOR
CENTER TANK FORWARD PROBE UPPER END

FUEL QUANTITY PROBE

FTX80761

Figure 28-47



MAIN TANK LOW LEVEL LIGHT (AMBER PRESS TO TEST)
ILLUMINATES WHEN THE FUEL LEVEL IN THE CORRESPONDING OUTBOARD MAIN TANK DROPS BELOW APPROX 2325 IF THE WINGS ARE NOT LEVEL THE LIGHT MAY COME ON AT A HIGHER OR LOWER LEVEL

ALTERNATE LOW LEVEL LIGHT (AMBER, PRESS TO TEST)
THE LIGHT STARTS FLASHING WHEN THE FUEL LEVEL IN THE OUTBOARD OR INBOARD ALT. SECTION DROPS BELOW FULL, WHILE THE CORRESPONSING MAIN TANK CONTAINS 4080 OR MORE. THE LIGHT IS ALSO ACTIVATED WHEN THE FUEL LEVEL IN THE OUTBOARD ALT SECTION DROPS BELOW FULL WHILE THE INBOARD SECTION CONTAINS 1025 OR MORE

THESE FLOAT SWITCHES CLOSE WHEN THE FUEL LEVEL IN THE OUTBOARD SECTION DROPS APPROX 75 BELOW FULL

CLOSES WHEN FUEL LEVEL IN THE INBOARD SECTION IS ABOVE APPROX. 1025

CLOSES WHEN FUEL LEVEL DROPS BELOW APPROX. 2325

CLOSES WHEN FUEL LEVEL IN THE INBOARD SECTION DROPS APPROX 175 BELOW FULL

CLOSED WHEN FUEL LEVEL IS ABOVE APPROX 4080

RESERVOIR
THE RESERVOIR MUST ALWAYS BE FILLED IN ORDER TO OBTAIN CORRECT FUEL QUANTITY INDICATION. IF NOT FILLED, THE INDICATION MAY BE UP TO 660 TOO LOW WHEN THE MAIN TANK LOW LEVEL WARNING COMES ON

FUEL TANK LEVELS

Figure 28-51

(4) Magnetic Fuel Measuring Stick (See Figure 28-48)

(a) The magnetic fuel measuring sticks are nonelectric, hand-operated indicators that are used to visually gage the amount of fuel in the tanks without risk of spillage. They are operated externally from beneath the wing.

(b) Each stick is contained in a flanged housing mounted inside the tank on the lower wing skin. The housing, which is attached to the outer tube assembly, encloses the calibrated measuring stick. The calibrated fuel measuring stick contains a magnet in the top portion of the tube.

(c) The barrel of the outer tube assembly is encircled by a doughnut-type float which contains a circular magnet inside the center opening. The float can move freely on the tube. The lower end of the fuel measuring stick is flush with the wing lower plating. The face of the stowage latch and locking cover are placarded to indicate the stowed (locked) and unlocked position. In the retracted position the inner measuring stick is securely locked into the locking cover.

C. Operation

(1) The indicated fuel is a function of the volume of fuel in the tank, and fuel dielectric constant. The fuel quantity probes that are located in each fuel tank measure the volume of fuel within that tank by varying the probe capacitance as the tank fuel level changes. The fuel has dielectric constant of approximately twice that of air. As the tank fuel level rises, the probe capacitance increase due to the increase in dielectric between the probe plates. Therefore, the voltage across the probe plates varies with the fuel level in the tank.

(2) The compensator is placed in the fuel quantity indicator circuit so that it will compensate for the effect of different dielectric constants of fuels. Mechanically, it is a fixed-type capacitor. However, it functions as a variable capacitor in the indicator bridge circuit since its capacitance varies with the dielectric constant of the fuel. The voltage measured across the compensator plates is constant for any one sample of fuel. However, upon refueling the fuel dielectric constant changes and the voltage across the compensator plates changes in value. The same change in fuel dielectric constant also affects the fuel quantity probes and thus the changing fuel dielectric constant is cancelled out in the indicator bridge circuit.

NOTE: **The compensator plate must be submerged in fuel to obtain an accurate fuel quantity indication on the indicator.**

(3) The fuel quantity indicator receives a signal voltage which is the sum of the voltages developed across the compensator and fuel quantity probes. This signal is summed with a voltage from the followup potentiometer at the amplifier input. The resulting voltage is amplified within the indicator and is used to drive a motor which positions the indicator dial display. As the dial display moves, the followup potentiometer reduces the original signal at the amplifier input. When the amplifier input signal reaches a null voltage, the motor stops turning and the correct fuel quantity is shown on the indicator.

NOTE: **If the system electrical power fails, the indicator pointer and counter tend to remain in their last indicated positions.**

(4) The totalizer (total fuel quantity indicator) indicates the total weight of the fuel on board the airplane. The totalizer amplifier receives an input signal voltage from each fuel quantity indicator (totalizer potentiometer) through the totalizer amplifier input summing network. The operation of the totalizer indicator is similar to the fuel quantity indicators noted above. The tank can be automatically filled to a fuel level other than full. To fill the tank to an intermediate level, the corresponding tank fill valve must close when the intermediate fuel level is reached. The desired fuel level is selected by positioning the fueling pointer on the indicator dial at the desired fuel weight. The pointer is positioned by the set knob that is located on the front of the indicator. The set knob also adjusts a switch in the instrument. The switch is set to close when the fuel quantity indication pointer passes the fueling pointer. When the switch is closed, 28-VDC power is supplied to the tank fill valve motor, closing the fill valve and stopping the flow of fuel into the tank.

11. Fuel Low Level Indicating Light System - Description And Operation

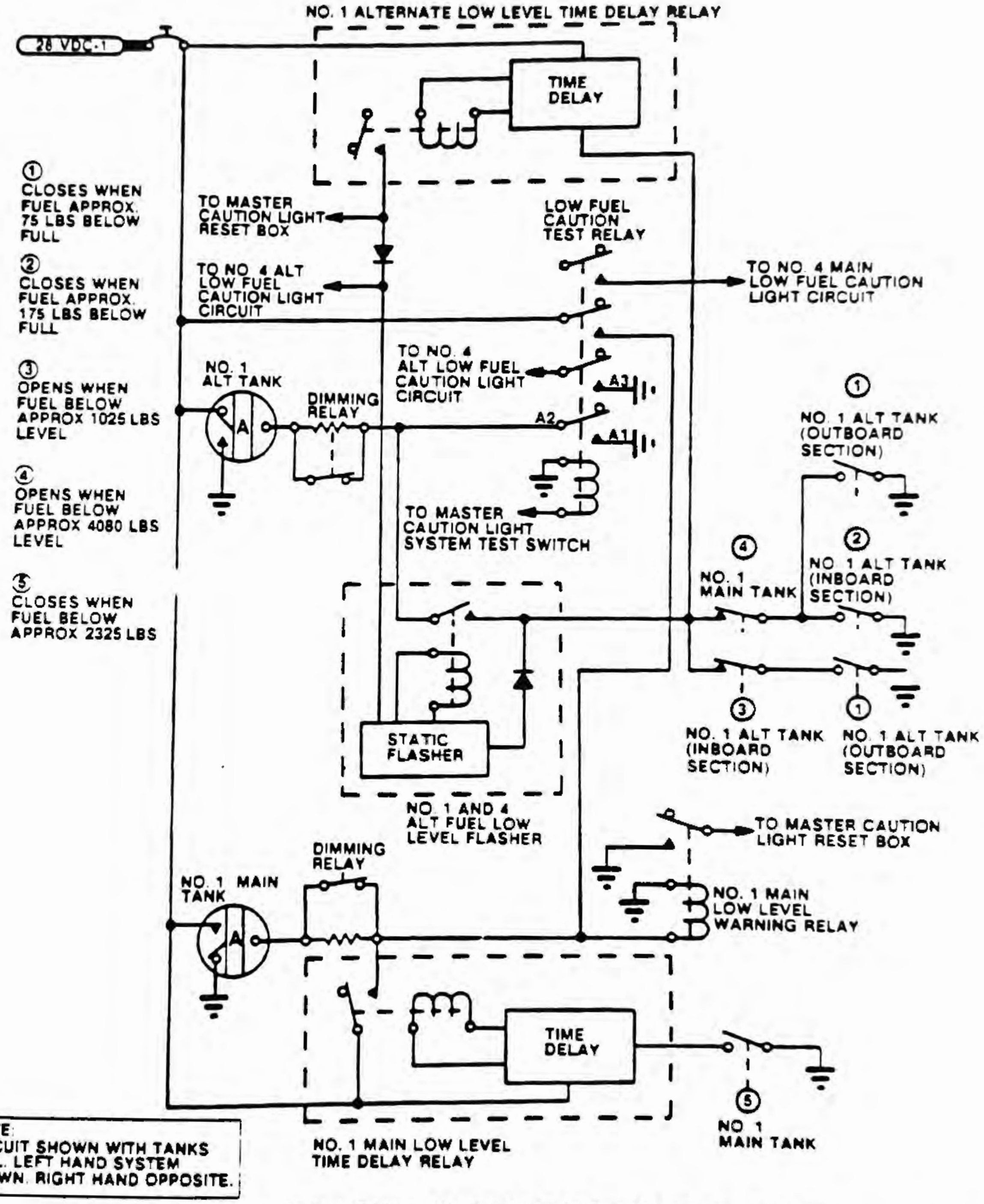
A. General

A fuel low level indicating light system is installed in the No. 1 and the No. 4 main and alternate tanks to assist in monitoring normal fuel management. The right wing and left wing systems are identical and are linked through a common flasher.

B. Description (See Figures 28-49 and 28-50)

(1) Each wing system consists basically of amber indicating lights operated by float switches in the alternate tanks and the No. 1 and No. 4 main tanks. A dimming relay is also included in the circuit. The indicating lights are located on the fuel control panel in the flight compartment. Power for the system is supplied from a 28 VDC bus through circuit breakers located on the fuel management and engine section of the electrical power center circuit breaker panel.

(2) The fuel low level indicating light float switches are float- operated magnetic switches. The switch assembly consists of a hermetically sealed glass enclosed switch, two float supported magnets, and a perforated shell.


NO. 1 ALTERNATE LOW LEVEL TIME DELAY RELAY
28 VDC-1
TIME DELAY
TO MASTER CAUTION LIGHT RESET BOX
TO NO. 4 ALT LOW FUEL CAUTION LIGHT CIRCUIT
LOW FUEL CAUTION TEST RELAY
TO NO. 4 MAIN LOW FUEL CAUTION LIGHT CIRCUIT
TO NO. 4 ALT LOW FUEL CAUTION LIGHT CIRCUIT
NO. 1 ALT TANK
DIMMING RELAY
A3
A2
A1
A
①
NO. 1 ALT TANK (OUTBOARD SECTION)
TO MASTER CAUTION LIGHT SYSTEM TEST SWITCH
④
NO. 1 MAIN TANK
②
NO. 1 ALT TANK (INBOARD SECTION)
STATIC FLASHER
③
NO. 1 ALT TANK (INBOARD SECTION)
①
NO. 1 ALT TANK (OUTBOARD SECTION)
NO. 1 AND 4 ALT FUEL LOW LEVEL FLASHER
TO MASTER CAUTION LIGHT RESET BOX
DIMMING RELAY
NO. 1 MAIN TANK
NO. 1 MAIN LOW LEVEL WARNING RELAY
TIME DELAY
⑤
NO. 1 MAIN TANK
NO. 1 MAIN LOW LEVEL TIME DELAY RELAY

① CLOSES WHEN FUEL APPROX. 75 LBS BELOW FULL

② CLOSES WHEN FUEL APPROX. 175 LBS BELOW FULL

③ OPENS WHEN FUEL BELOW APPROX 1025 LBS LEVEL

④ OPENS WHEN FUEL BELOW APPROX 4080 LBS LEVEL

⑤ CLOSES WHEN FUEL BELOW APPROX 2325 LBS

NOTE:
CIRCUIT SHOWN WITH TANKS FULL. LEFT HAND SYSTEM SHOWN. RIGHT HAND OPPOSITE.

FUEL LOW LEVEL INDICATING LIGHT SYSTEM FTX80763

Figure 28-49

C. Operation (See Figure 28-51)

(1) Vertical movement of the float, as a result of the rise or fall of fuel surrounding the switch, causes the switch to make or break contact as applicable. The switches, located in the outboard section of the alternate tanks close when the fuel level falls below the switch level. Switches located in the inboard section of the alternate tank and in the main tanks are closed when the fuel level is above the switch level.

(2) The alternate quantity low level indicating light flashes on and off if one of the following conditions occurs; level of the fuel in the outboard section of the alternate tank is low with the fuel level high in the inboard section; level of the fuel in either section of the alternate tank is low with the fuel level high in the corresponding main tank.

(3) The main quantity low level indicating light comes on steadily when the No. 1 and No. 4 main tank is near empty regardless of the level in the corresponding alternate tank.

(4) All low level caution lights will come on simultaneously when the master caution test switch is placed in the test position. Lights will go off when the test switch is released.

12. Reservoir Feed Pump Pressure Indicating System-Description and Operation

A. General

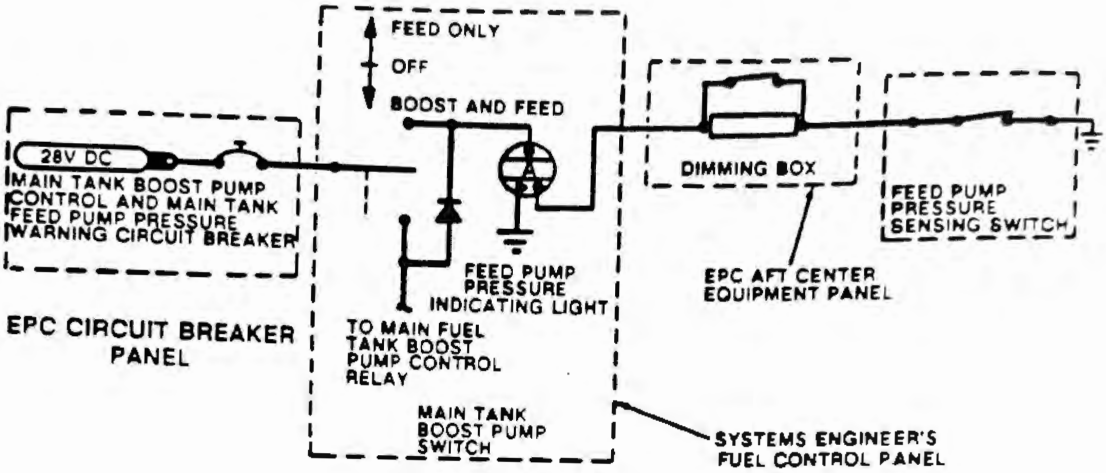
The reservoir feed pump pressure indicating system provides a visual indication to the systems engineer that the reservoir feed pump is functioning normally. For each main tank, there is a reservoir feed pump pressure indicating system. System electrical power is supplied through the main tank boost pump control and main tank feed pump pressure warning circuit breaker located on the fuel management and engine section of the EPC circuit breaker panel.

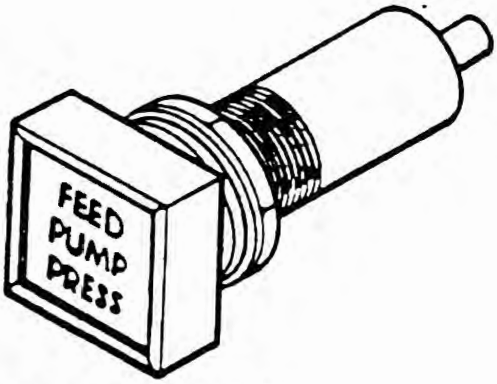
B. Description

Each system consists of a feed pump pressure-sensing switch, located on the wing front spar; an indicating light dimming box, located on the electrical power center aft center equipment panel; and a feed pump pressure indicating light and a main tank boost pump switch, both located on the systems engineer's fuel control panel.

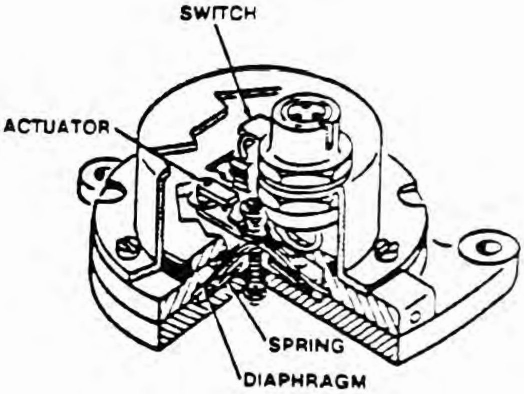
C. Operation (See Figure 28-52)

The feed pump pressure-sensing switch measures the differential fuel pressure between the feed pump inlet and outlet ports. When the feed pump is deenergized, the switch is in its normally closed position. When the corresponding feed pump circuit breaker is closed, the main tank boost pump switch is closed, and the feed pump is not delivering the required pressure of 1.25 psig, the feed pump pressure indicating light on the systems engineer's fuel control panel comes on. When the feed pump is energized, the switch is actuated to the open position by the feed pump pressure. The feed pump pressure indicating light goes off. If electrical power is applied to the indicating system and a reservoir feed system malfunction should occur during the feed pump operation, the pressure differential across the feed pump decreases, allowing the switch to close. The corresponding feed pump pressure indicating light comes on.


FEED ONLY
OFF
BOOST AND FEED
28V DC
MAIN TANK BOOST PUMP CONTROL AND MAIN TANK FEED PUMP PRESSURE WARNING CIRCUIT BREAKER
EPC CIRCUIT BREAKER PANEL
FEED PUMP PRESSURE INDICATING LIGHT
TO MAIN FUEL TANK BOOST PUMP CONTROL RELAY
MAIN TANK BOOST PUMP SWITCH
DIMMING BOX
EPC AFT CENTER EQUIPMENT PANEL
FEED PUMP PRESSURE SENSING SWITCH
SYSTEMS ENGINEER'S FUEL CONTROL PANEL



FEED PUMP PRESSURE INDICATING LIGHT



FEED PUMP PRESSURE-SENSING SWITCH

RESERVOIR FEED PUMP PRESSURE INDICATING SYSTEM

FTX80766

Figure 28-52

13. Tank Fuel Temperature Indicating - Description And Operation

A. General

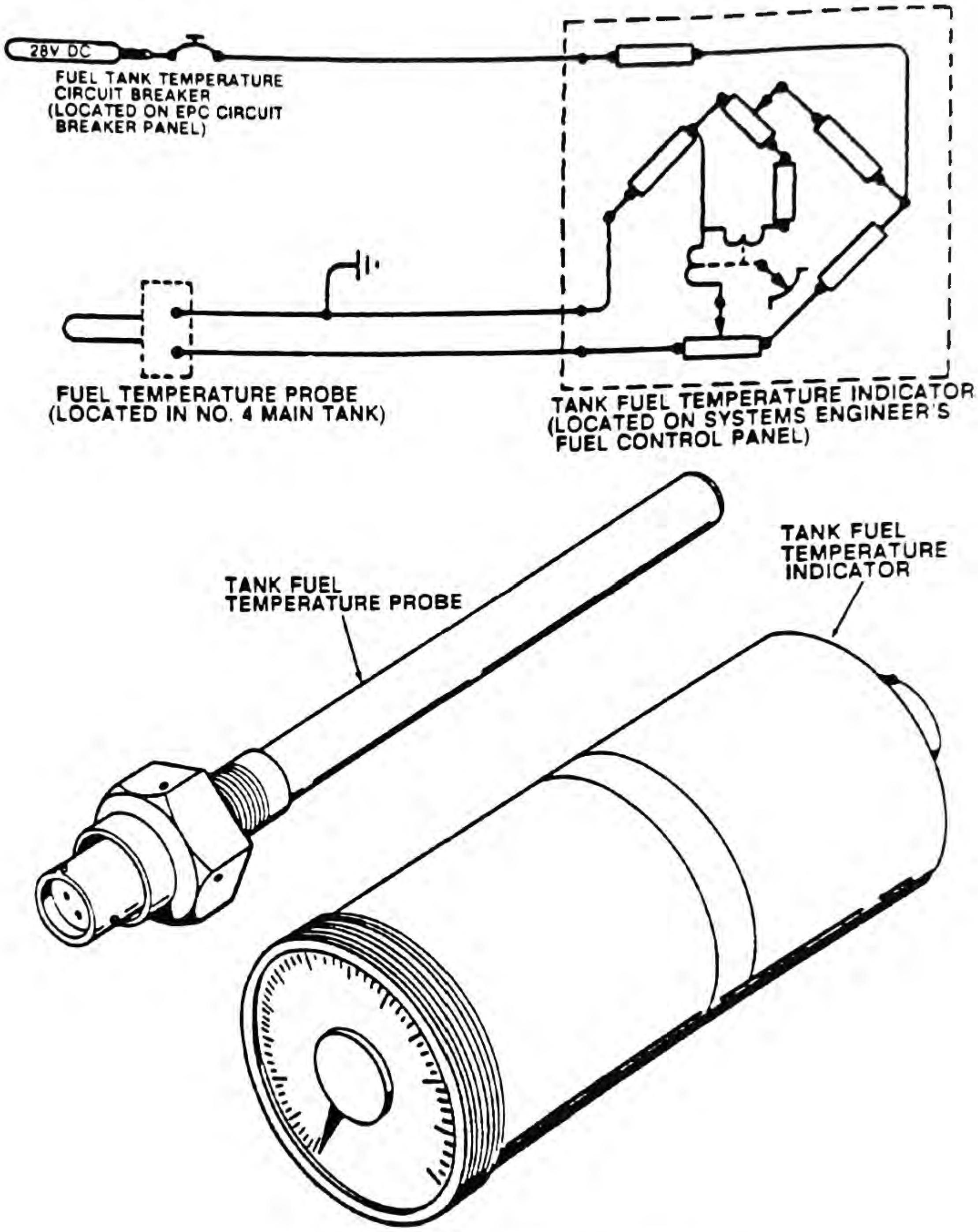
The tank fuel temperature indicating system is provided to indicate tank fuel temperature on an indicator located on the systems engineer's fuel control panel. From this temperature indication, the viscosity of the fuel can be determined. The fuel temperature indicating system requires 28-VDC for operation. The 28-VDC power is directed to the indicator through the fuel tank temperature circuit breaker located on the fuel management and engine section of the EPC circuit breaker panel.

B. Description (See Figure 28-53)

The fuel temperature indicator requires 25- to 29-VDC power source for operation and a 5-vac power source for the indicator integral lighting. The indicator is a ratiometer-type instrument which operates on the unbalanced bridge principle with the fuel temperature probe, located on the aft spar of the No. 4 main fuel tank, as one leg of the bridge circuit. The dial of the indicator is calibrated to read fuel temperature from -70 degrees C to 50 degrees C with the 0 degrees C temperature at the top of the dial. An electrical receptacle is provided on the indicator.

C. Operation

The tank fuel temperature indicating system is a ratiometer-type system operating on the unbalance bridge principle. The temperature probe is the variable in the bridge circuit. As the temperature of the fuel changes, the fuel temperature probe (one leg of the bridge circuit) changes resistance value, thus unbalancing the indicator bridge circuit. The unbalanced bridge causes the current flow to change through the motor windings, changing the magnetic field acting on the motor armature, and repositioning the indicator pointer at the correct fuel temperature.


28V DC
FUEL TANK TEMPERATURE CIRCUIT BREAKER (LOCATED ON EPC CIRCUIT BREAKER PANEL)
FUEL TEMPERATURE PROBE (LOCATED IN NO. 4 MAIN TANK)
TANK FUEL TEMPERATURE INDICATOR (LOCATED ON SYSTEMS ENGINEER'S FUEL CONTROL PANEL)
TANK FUEL TEMPERATURE PROBE
TANK FUEL TEMPERATURE INDICATOR

TANK FUEL TEMPERATURE INDICATING SYSTEM

FTX80767

Figure 28-53

TOTAL FUEL LOAD	1 & 4 ALT				1 & 4 MAIN			2 & 3 MAIN			CW AUX		FWD AUX		
	LBS.	STICK			LBS.	STICK		LBS.	STICK		LBS.	STICK	LBS.	STICK	
		INB	CTR	OBD		INB	OBD		INB	OBD				INB	OBD
30,000	4,500	5		FULL READS QUANTITY IN TIP TANK ONLY	3,000	10		7,500	8 1/2						
35,000	5,750	8 1/2			3,000	10		8,750	10 1/2						
40,000	7,000	11 1/2			3,000	10		10,000	12						
45,000	8,250		2		3,000	10		11,250	13 1/2						
50,000	9,500		5		3,000	10		12,500	15 1/2						
55,000	10,750		10		3,000	10		13,750	17						
55,000	10,995		10 1/2		3,000	10		13,995	17						
60,000	10,995		INCLUDES QUANTITY IN TIP TANK ONLY		4,005	12 1/2		15,000	18 1/2						
65 000	10,995				5,255	15		16,250	20 1/2						
70,000	10,995				6,505	17		17,500	22						
75,000	10,995				7,755	19		18,750	23 1/2						
80,000	10,995				9,005	21		20,000	25						
85,000	10,995				10,255		7 1/2	21,250	27						
90,000	10,995				11,505		9	22,500	28 1/2						
95,000	10,995				12,755		10 1/2	23,750	30						
100,000	10,995				14,005		12 1/2	25,000	32						
105,000	10,995				15,255		14	26,250		23 1/2					
110,000	10,995				16,505		16	27,500		25 1/2					
115,000	10,995				17,755		18	28,750		28					
119,364	10,995				18,846		20 1/2	29,841		31					
120,000	10,995				19,164		21	29,841		31					
121,054	10,995				19,691		22	29,841		31					
125,000	10,995				19,691		22	29,841		31	3,946	6 1/2			
130,000	10,995				19,691		22	29,841		31	8,946	14			
135,000	10,995				19,691		22	29,841		31	13,946	21			
140,000	10,995				19,691		22	29,841		31	18,946	28 1/2			
145,000	10,995				19,691		22	29,841		31	23,946	35			
149,087	10,995				19,691		22	29,841		31	28,033	43 1/2			
150,000	10,995				19,691		22	29,841		31	28,033	43 1/2	913	5	
155,000	10,995				19,691		22	29,841		31	28,033	43 1/2	5,913	18	
160,000	10,995				19,691		22	29,841		31	28,033	43 1/2	10,913		8
162,534	10,995				19,691		22	29,841		31	28,033	43 1/2	13,447		15

FUEL QUANTITY DISTRIBUTION

FTX60786

Figure 28-54

-61 DIFFERENCES

1. General - Description And Operation

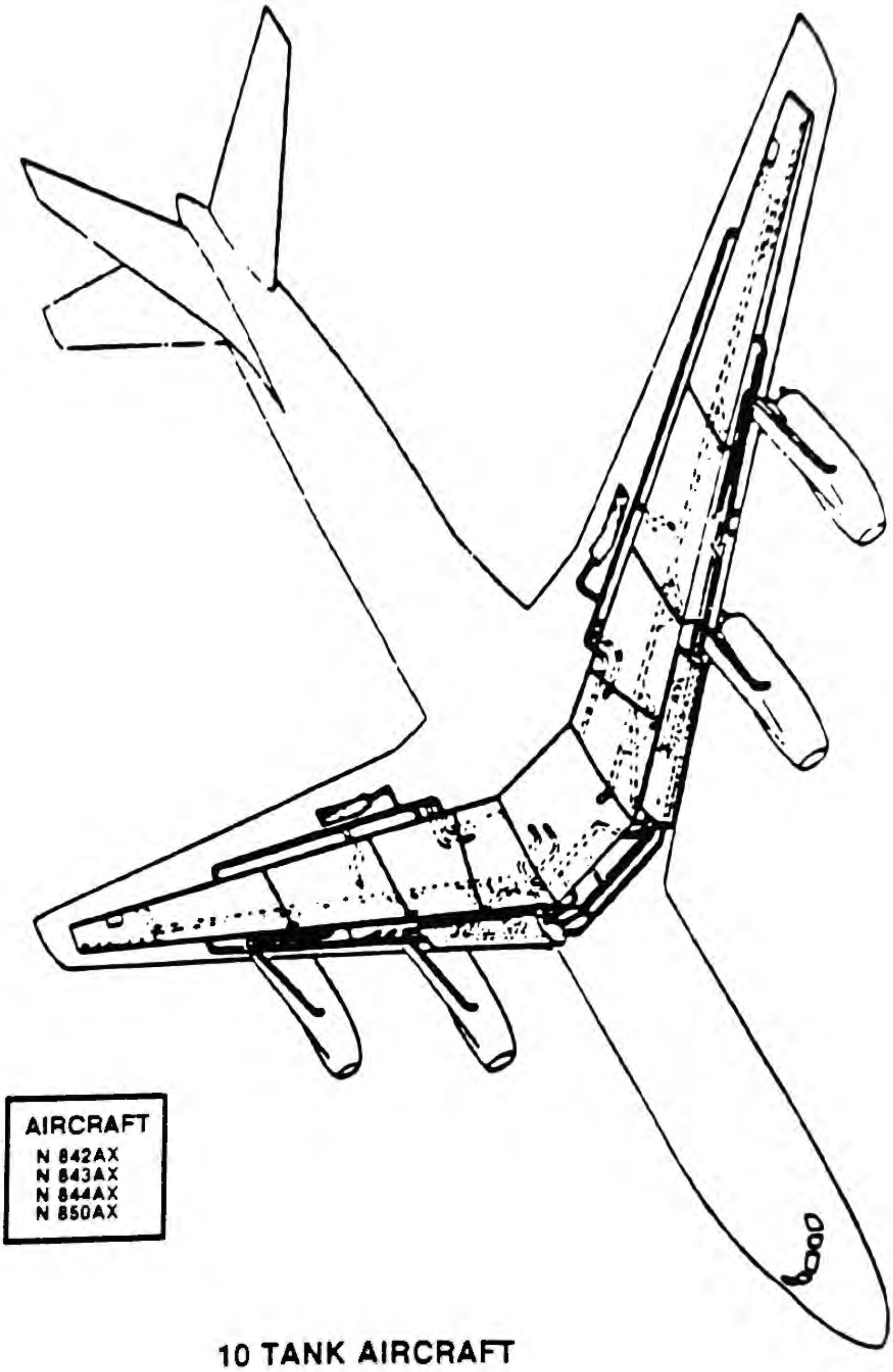
A. Description (See Figures 28-55, 28-56, and 28-57)

(1) The airplane fuel system is divided into storage, distribution, dump, and indicating. Storage includes tanks and sealing, vent system, and reservoir feed systems. Distribution includes the tank fill system and the engine fuel supply system up to and including the fuel shutoff valves in the engine pylons. The dump is concerned with dumping fuel overboard. The indicating system includes fuel quantity indicating, reservoir feed pump pressure indicating, low-level warning, and fuel temperature indicating system.

(2) ABX sixty-one series aircraft have three different tank configurations. They are eight tank, nine tank, and ten tank aircraft. The ten tank aircraft will be covered in this study guide.

(3) The fuel system contains ten integral tanks. Eight tanks are paired, two to each engine. There is one main and one alternate tank numbered to correspond to the applicable engine. The ninth tank is in the center wing. The tenth tank consists of the left and right leading edge tanks which are joined together by a crossover line. The tanks can be filled individually or simultaneously through the pressure refueling adapters connected to the crossfeed manifold. The tanks can also be gravity fueled through the auxiliary fill adapters in the upper wing surface. The engine fuel supply system utilizes the same crossfeed system as the tank fill system to accomplish crossfeeding and fuel transfer.

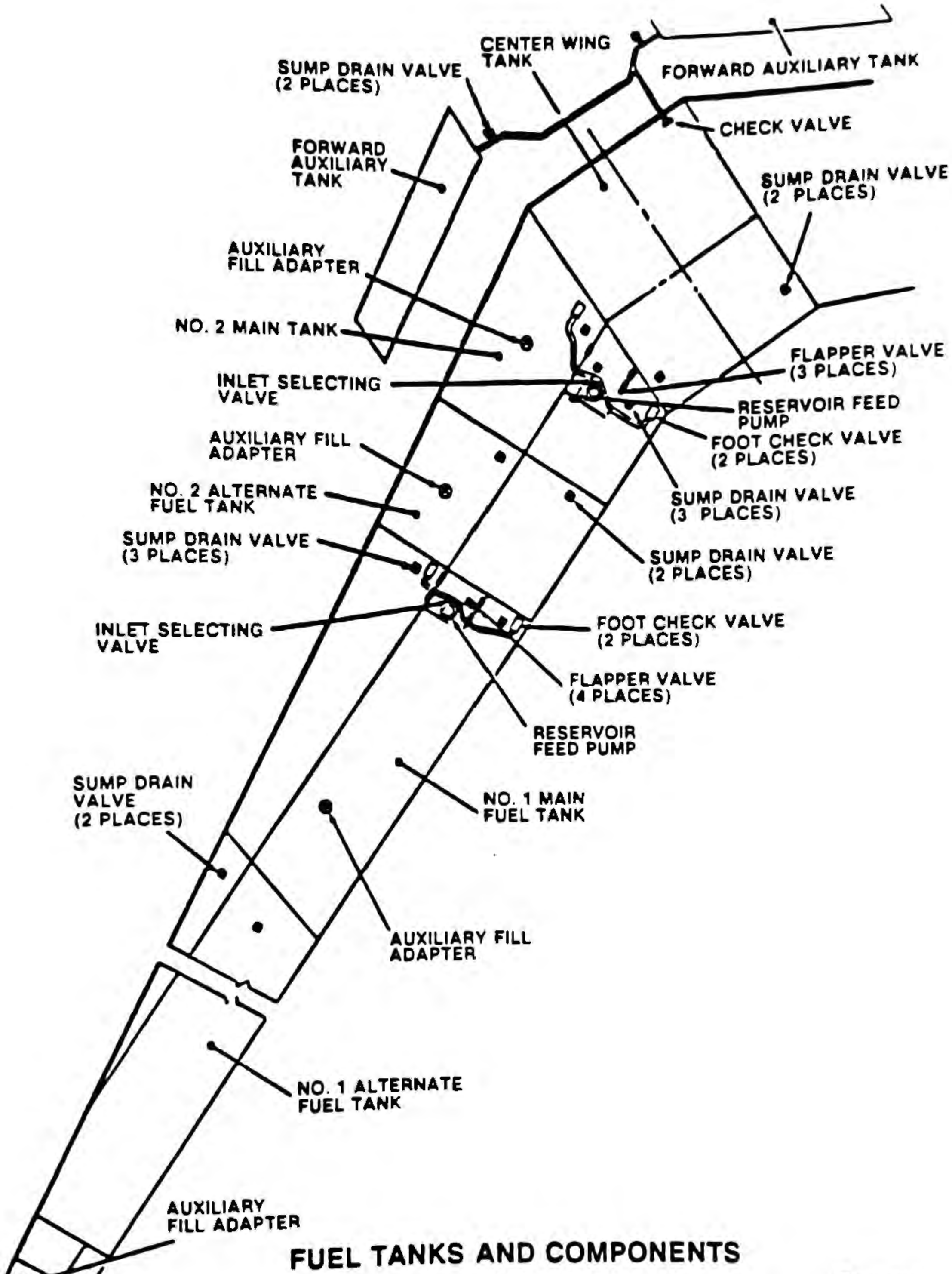
(4) The controls and indicators for the fuel system are located in the flight compartment.



10 TANK AIRCRAFT

FTX80768

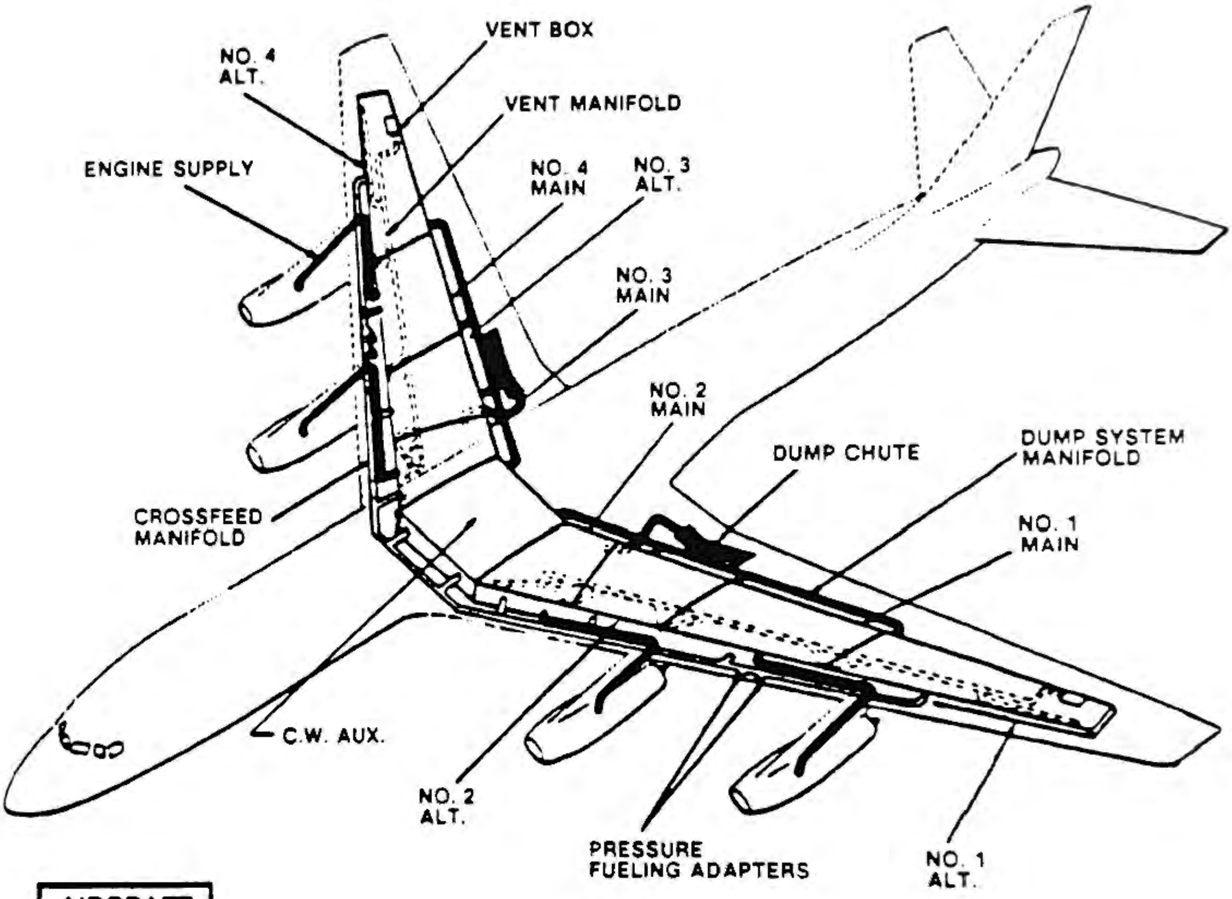
Figure 28-55



FUEL TANKS AND COMPONENTS

FTX80772

Figure 28-59

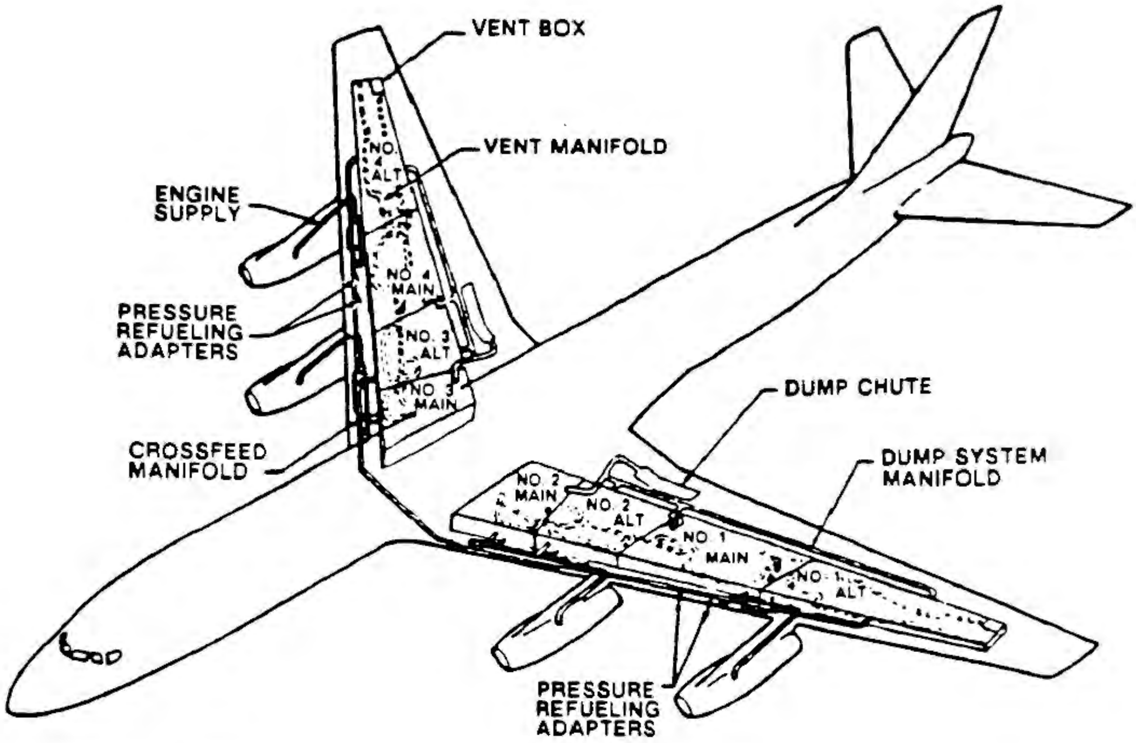


AIRCRAFT
N 841AX
N 845AX
N 846AX
N 847AX
N 848AX

9 TANK AIRCRAFT

FTX80769

Figure 28-56



AIRCRAFT
N 851AX

8 TANK AIRCRAFT

FTX80770

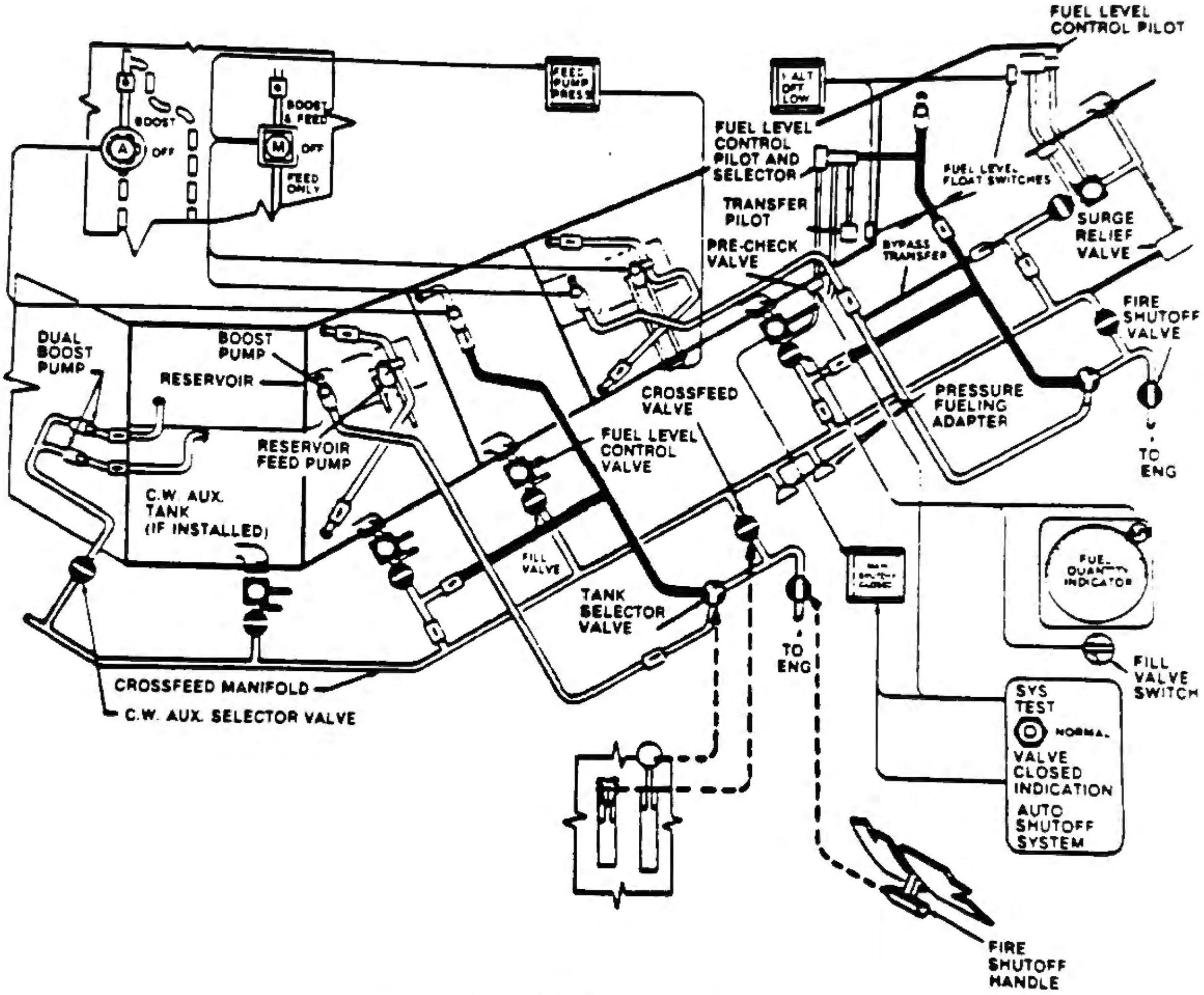
Figure 28-57

2. Storage - Description And Operation

A. General (See Figure 28-58)

(1) The fuel storage system consists off the fuel tanks and components, and the vent system. The tanks are integral with the wing. Flapper valves are located in closing bulkheads, in the inboard end of each main tank, to form a reservoir. Sump drain valves are provided in the lower portion of all tanks to permit draining of residual fuel. Auxiliary fuel servicing is accomplished by means of overwing fuel tank fill adapters, one in each tank upper wing skin.

(2) A vent system is provided to prevent overboard fuel spillage during ground or flight maneuvers. The system also prevents tank overpressure during filling and maintains pressure differential between the tank and ambient pressure, within allowable limits, for all airplane flight conditions.



FUEL SYSTEM SCHEMATIC

FTX80771

Figure 28-58

3. Description Fuel Tanks And Components

A. Fuel Tanks (See Figure 28-59)

(1) Ten integral wing fuel tanks provide storage for fuel. There are four main tanks, four alternate tanks, with the alternate tanks outboard of their respective main tanks; one centerwing tank, and two leading edge tanks connected by a crossover line to form the tenth tank. The front and rear walls of the main and alternate tanks are formed by the front and rear wing spars. Fuel tight bulkheads form the inner and outer walls of these tanks with the upper and lower wing panels forming the top and bottom of the tanks.

(2) The wing tanks are numbered from left to right respectively: No. 1 alternate, No. 1 main, No. 2 alternate, No. 2 main, No. 3 main, No. 3 alternate, No. 4 main, and No. 4 alternate.

(3) Each main tank has an integral reservoir in the inboard end that retains fuel to keep the fuel boost pump submerged at all normal flight attitudes. The reservoir is immediately aft of the center spar between the wing upper and lower panels. The forward and aft walls of the reservoir are stepped to reduce the amount of unusable fuel at extreme flight attitudes. The reservoir is formed by closing the second and sixth inboard bulkheads with flapper valves. These valves permit fuel to flow inboard but prevent fuel from flowing outboard away from the boost pumps in a wing-low attitude or other similar situation. The retained fuel provides a head of fuel to keep the boost pumps submerged at all normal flight attitudes and during all normal maneuvers.

(4) The primary means of tank internal sealing is a close-tolerance metal-to-metal fit. Sealant is used for bead seals, dams, and faying seals. Corrosion protection is provided by a polyurethane covering on the bottom and lower 4 inches of the tank sidewalls.

(5) The top surface of the center wing constant section and forward face of the center wing front spar which forms a part of the center wing fuel tank are sealed with a fuel vapor barrier coating material. The coating is applied to these external areas of the tank by brushing

and/or spraying. The vapor barrier coating acts as an additional sealant to prevent fuel vapors from escaping the tank and entering the pressurized areas of the fuselage.

(6) To insure complete sealing of the tank top surface, a mylar patch is cemented over fuel tank access doors and fuel quantity probe access covers.

B. Sump Jet Pump (See Figure 28-60)

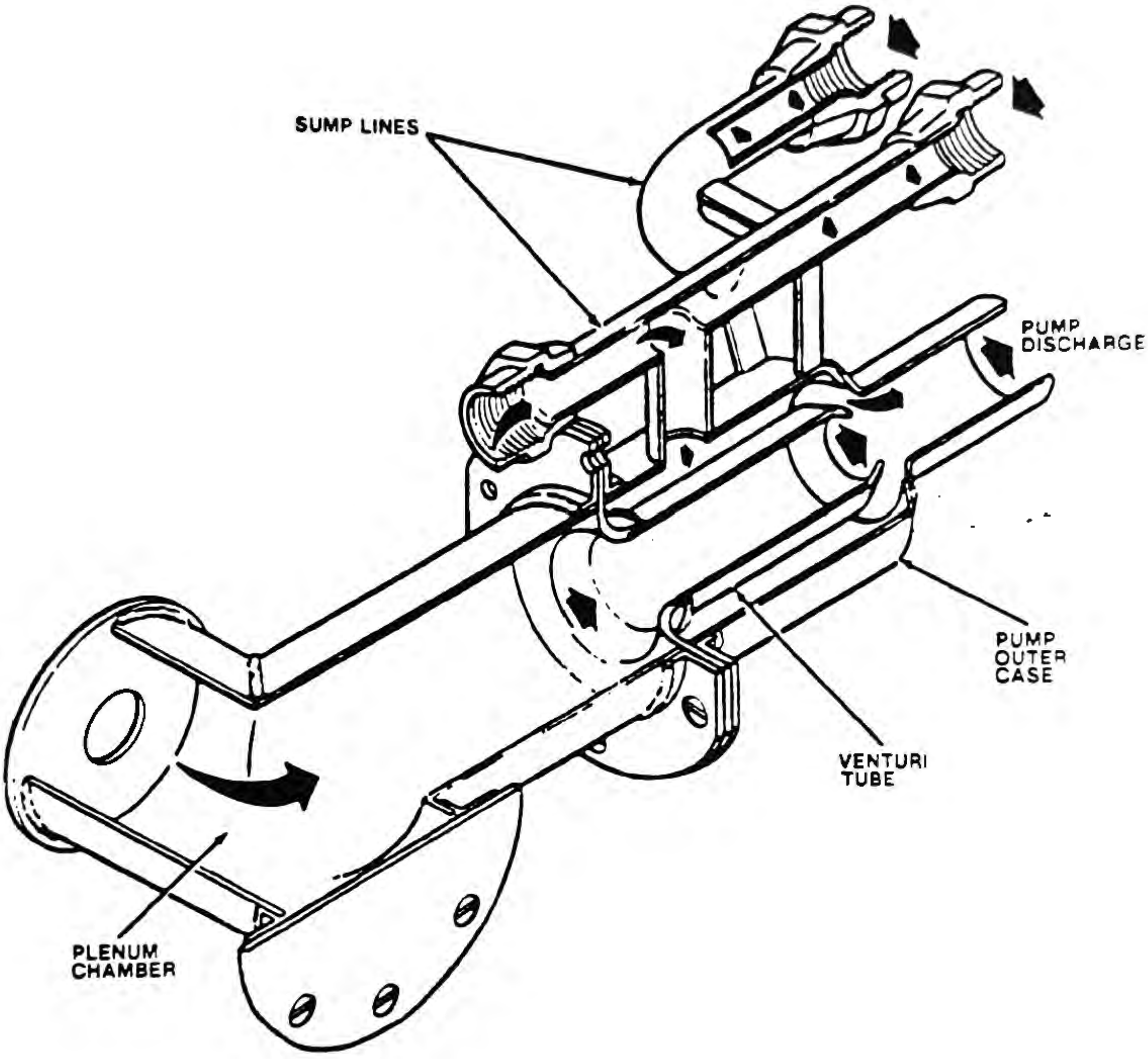
(1) There is a sump jet pump located in each main tank reservoir. The jet pump is connected to the discharge end of the reservoir feed pump. The jet pump sucks fuel from the main tank sump through lines connected to the sump drain valves.

(2) The jet pump consists of a venturi tube mounted concentrically within the pump outer case. Three sump lines connect to the pump outer casing. A plenum chamber is attached to the jet pump between the reservoir feed pump discharge end and the jet pump intake end. Fuel discharged by the reservoir feed pump enters the plenum chamber and passes through the venturi drawing with it fuel from the sump drain lines. The fuel is discharged into the tank reservoir.

C. Sump Line Check Valve (See Figure 28-60)

(1) There is one sump line check valve installed in each of the three sump lines leading to the sump jet pump. The sump line check valve consists basically of a spring-loaded, hinged, flapper enclosed in a barrel shaped body. Threaded fittings are provided on each end of the valve for line connections.

(2) The valve prevents fuel flow reversal in the sump lines.



SUMP JET PUMP - SCHEMATIC

FTX80773

Figure 28-60

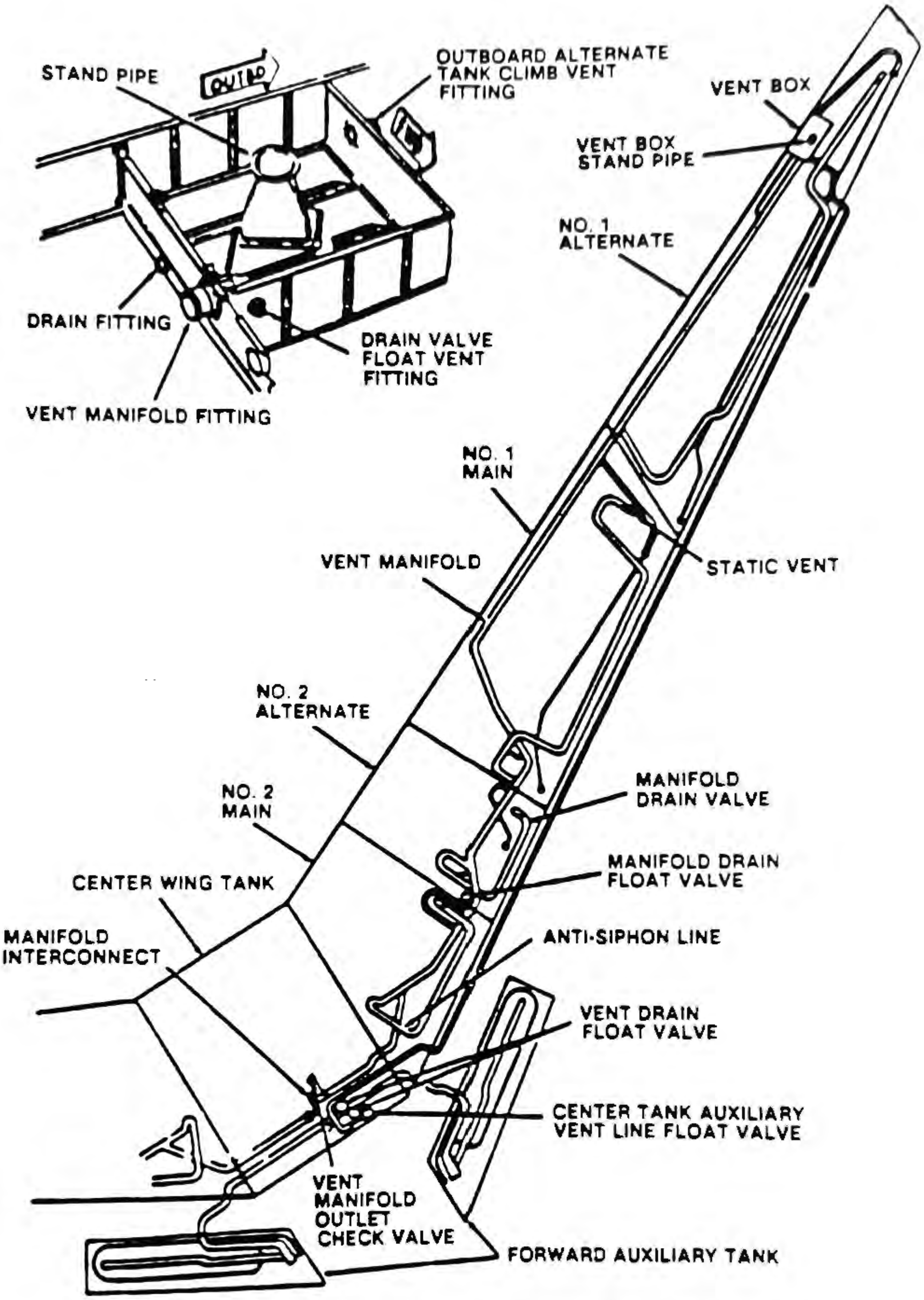
4. Description Vent System and Components

A. Vent System (See Figure 28-61)

(1) The fuel tank vent system provides venting from the tanks during tank refueling and airplane ascent, and into the tanks during fuel usage and descent. Venting prevents the development of an excessive pressure differential that could damage the wing structure. The vent system also prevents structural damage by allowing fuel to flow overboard from the tanks in the event of a tank overfilling due to a fill system malfunction.

(2) The vent system consists of four subsystems; a left wing subsystem, a right wing subsystem, a forward auxiliary vent subsystem, and a center wing tank auxiliary vent subsystem. Each wing vent subsystem vents the main and alternate tanks of its respective wing. Although the two wing subsystems are interconnected, the center wing tank is primarily vented by the left wing subsystem The forward auxiliary tank vent subsystem vents into the center wing tank. The center wing tank auxiliary vent subsystem vents the forward auxiliary and center wing tanks when the wing vent subsystem contains trapped fuel due to stepped climb. Each wing subsystem consists of a vent trap, a manifold which runs from the inboard tank to the vent trap, climb and static vents, and drain valves which tee into the manifold. The vent traps are located in the outboard alternate tanks and at high points in the system. The drain valves are located in the inboard alternate tanks and in the center wing tank, and are at the lowest points in the system. Each tank has a static vent and a climb vent which are connected into a common manifold. The vents are located so that one of the two vent inlets in each tank is exposed to the airspace above the fuel in any normal airplane attitude. With full tanks, the climb vents are submerged when the airplane is in the static ground attitude but are exposed to air when the airplane is within a climb angle of 6 to 7 degrees (or equivalent level acceleration). Either of the two vents (but not both) may become submerged during certain roll attitudes, depending on the direction of roll. Drain lines connect low points in the static vent pipes to the manifold.

(3) The vent trap consists of a vent box and an overboard standpipe and has a capacity of approximately 200 pounds (30 gallons of fuel). This quantity is the total amount of fuel which will enter the tank static



VENT SYSTEM AND COMPONENTS - SCHEMATIC FTX60774

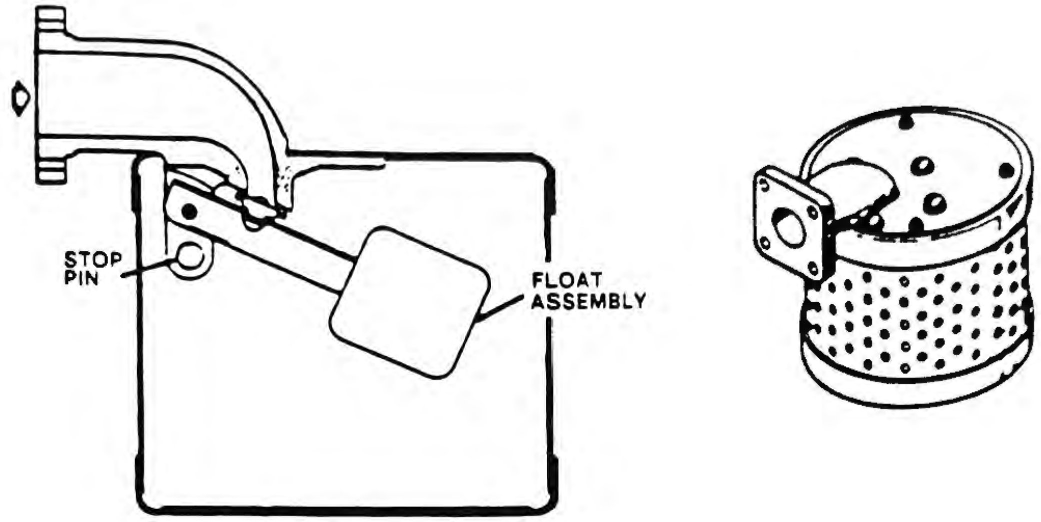
Figure 28-61

vents during climb and/or forward acceleration if all the tanks are full. When the airplane is leveled out, this fuel flows into the manifold and inboard into the tanks from which fuel is being used. However, if the airplane is immediately returned to an extreme climb angle, this fuel will flow outboard and fill the vent trap, but it will not spill overboard. A drain float valve is installed in alternate tanks No. 2 and 3, and a drain check valve is installed in the center wing auxiliary tank. If the fuel level is below the 5,000 pound level in alternate tanks No. 2 and 3, or below the 24,000 pound level in the center wing auxiliary tank, the drain float valve (or drain check valve) automatically drains liquid from the manifold into the tanks. A manual drain valve is installed in alternate tanks No. 2 and No. 3. The manual drain valve is tool-operated, and is used to drain sediment water overboard. Due to the common manifold, conditions of extreme thermal expansion may cause a small quantity of fuel to be displaced from the outboard to the inboard tanks when the tanks are full.

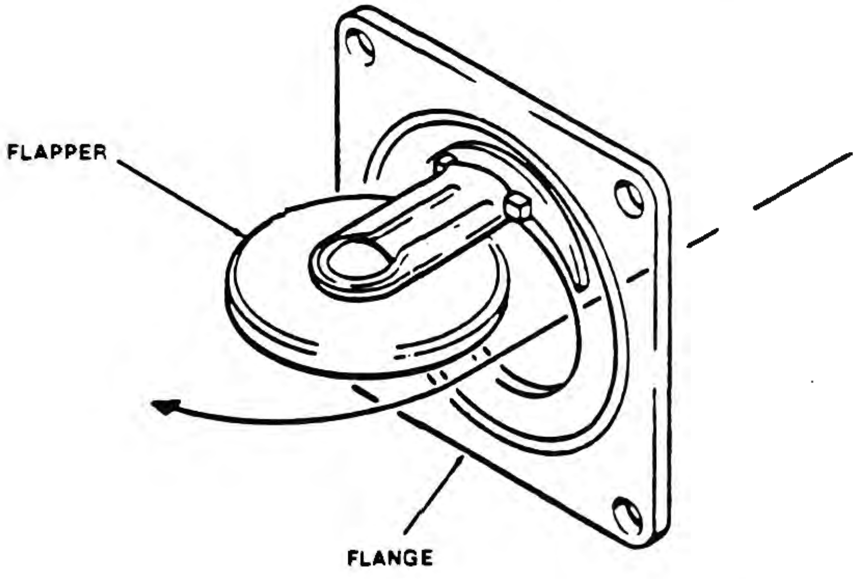
B. Vent Manifold Drain Float Valves (See Figure 28-62)

(1) There is one vent manifold drain float valve located in each inboard alternate tank. The valves are connected into the low points of the vent manifold. The valves automatically drain any sediment or fuel from the manifold into the alternate tanks when the fuel level in these tanks decreases to below approximately 5200 pounds.

(2) The valve consists basically of a housing and a float. The float arm is attached to lugs to allow free swing. The self-aligning valve is attached to the top side of the arm and has a bonded seal that seats and mates to the attaching neck outlet opening. The float, which is seated or opened by the fuel level of the inboard alternate tanks, is held seated until approximately the 5200-pound fuel level is reached. At this point the float lowers, opens the valve, and automatically drains the manifold into the tank.



VENT MANIFOLD DRAIN FLOAT VALVE



VENT MANIFOLD OUTLET CHECK VALVE

FTX80775

Figure 28-62

C. Vent Manifold Manual Drain Valves

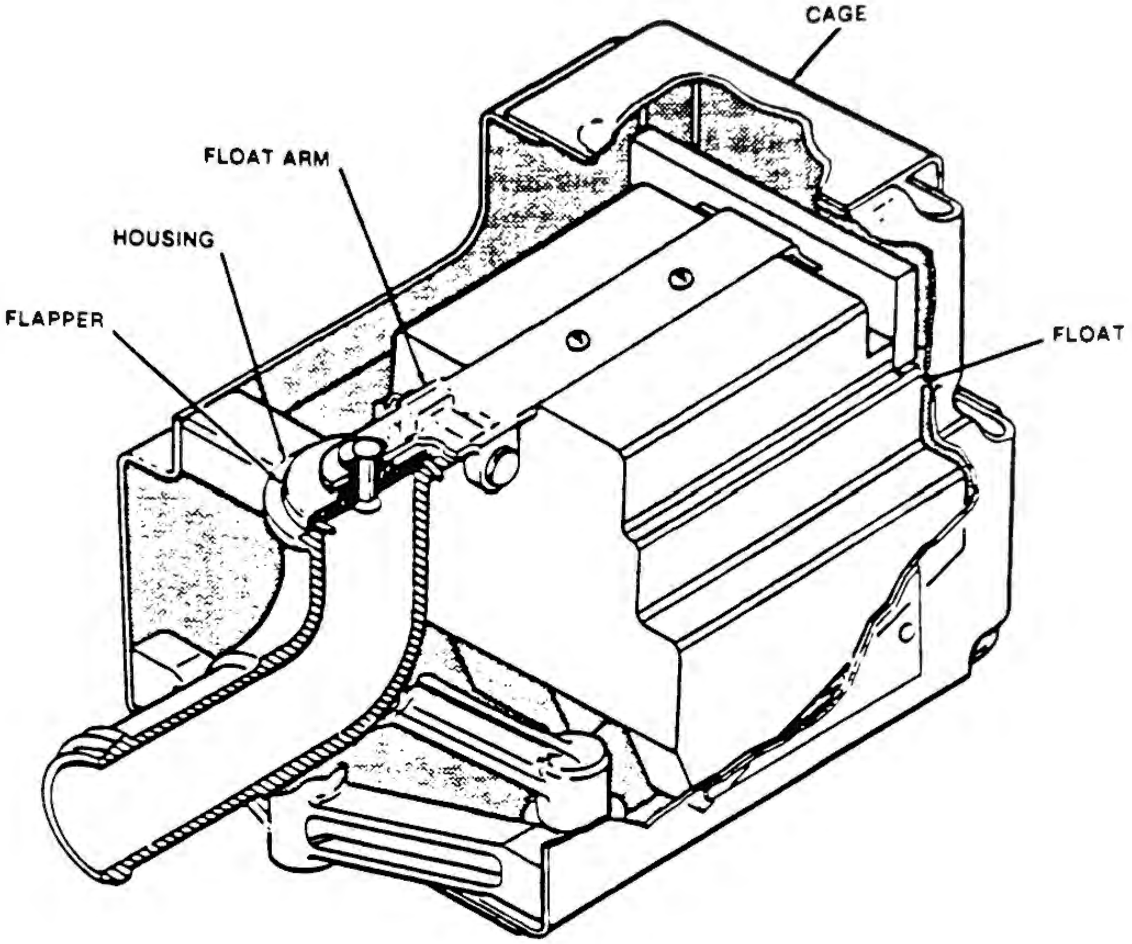
The vent manifold manual drain valves are installed, one each, in the inboard alternate tanks. The valves permit manual draining of the vent manifold during maintenance. The valves are identical to the sump drain valves except that the sump drain valves have a vent hole in the upper part of the valve housing.

D. Vent Manifold Outlet Check Valve (See Figure 28-62)

There is one vent manifold outlet check valve installed in the vent line leading from the junction of the main vent lines in the center tank. The check valve is of the swing check type. The valve consists basically of a flapper pinned to a flange base by a pin. This valve prevents fuel from surging back into the vent line from the center tank.

E. Center Tank Auxiliary Vent Line Float Check Valve (See Figure 28-63)

The center tank auxiliary vent float check valve is installed in the inboard end of the center tank auxiliary vent line in the center tank. The valve consists basically of a flapper attached by an arm to a counterweighted float. The flapper assembly is hinged to a housing. A cage encloses the complete assembly. The valve is mounted near the upper surface of the tank to provide center tank venting when the tank is near full. When the fuel level is below the level of the float the valve is open to provide venting. When the fuel surrounds the float the valve closes preventing loss of fuel.



CENTER TANK AUXILIARY VENT LINE FLOAT
CHECK VALVE - SCHEMATIC

FTX80776

Figure 28-63

5. Distribution - Description And Operation

A. General (See Figure 28-64)

The fuel distribution system is divided into the fuel tank fill system and the engine fuel supply system. The fill system is concerned with the distribution and control of fuel from the pressure fueling adapters to the fuel tanks. The engine fuel supply system is concerned with the routing of fuel from the fuel tanks up to and including the fuel shutoff valves located on the pylon firewall. The crossfeed manifold, which is considered a part of the distribution system, is also used for pressure fueling. Further description and operation of the fill system and the supply system will be covered under individual sections for each system.

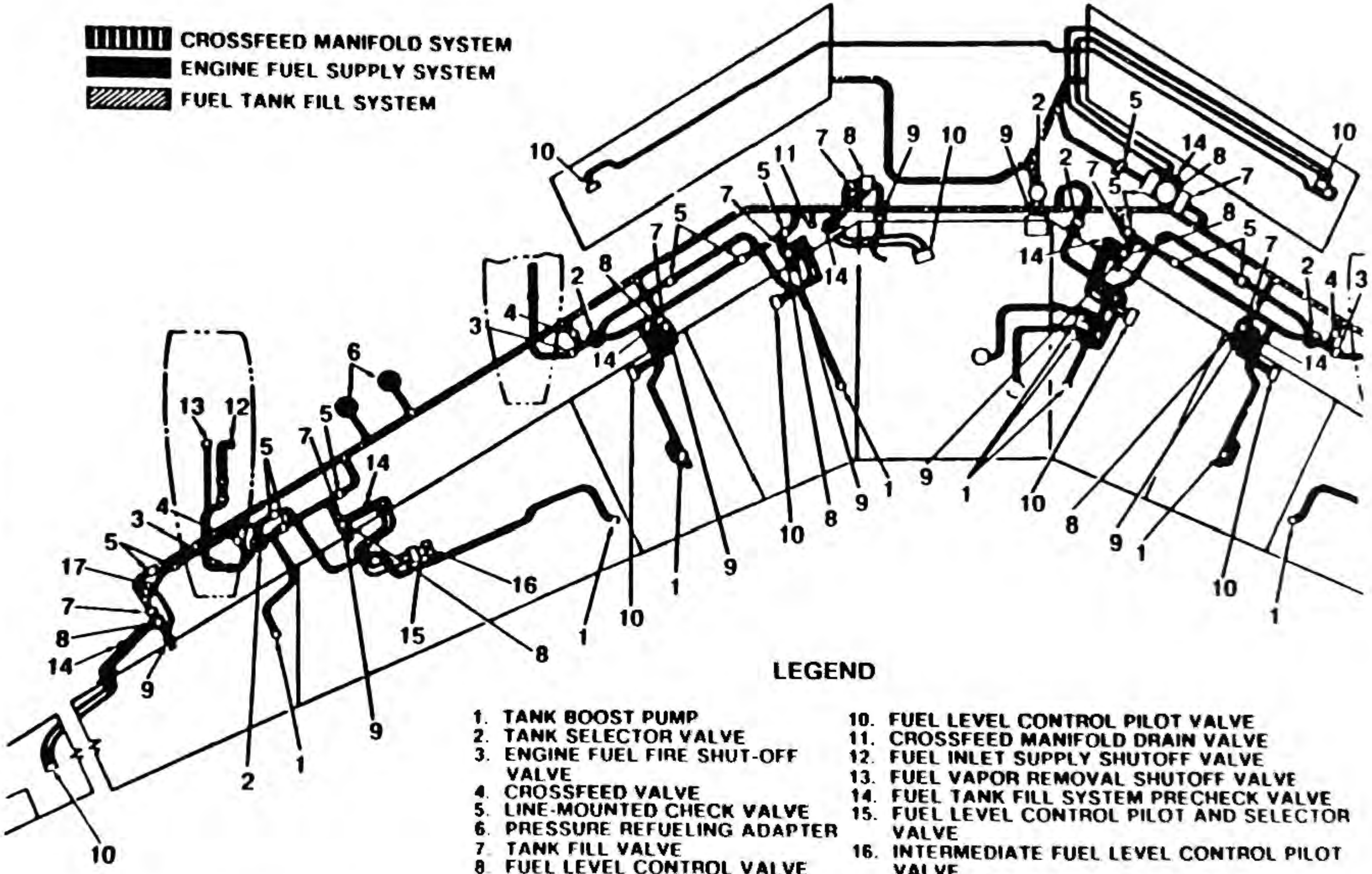


Figure 28-64

LEGEND

1. TANK BOOST PUMP
2. TANK SELECTOR VALVE
3. ENGINE FUEL FIRE SHUT-OFF VALVE
4. CROSSFEED VALVE
5. LINE-MOUNTED CHECK VALVE
6. PRESSURE REFUELING ADAPTER
7. TANK FILL VALVE
8. FUEL LEVEL CONTROL VALVE
9. TANK INLET CHECK VALVE
10. FUEL LEVEL CONTROL PILOT VALVE
11. CROSSFEED MANIFOLD DRAIN VALVE
12. FUEL INLET SUPPLY SHUTOFF VALVE
13. FUEL VAPOR REMOVAL SHUTOFF VALVE
14. FUEL TANK FILL SYSTEM PRECHECK VALVE
15. FUEL LEVEL CONTROL PILOT AND SELECTOR VALVE
16. INTERMEDIATE FUEL LEVEL CONTROL PILOT VALVE
17. SURGE PROTECTION RELIEF VALVE

DISTRIBUTION SYSTEM

FTX80777

6. Fuel Tank Fill System - Description And Operation

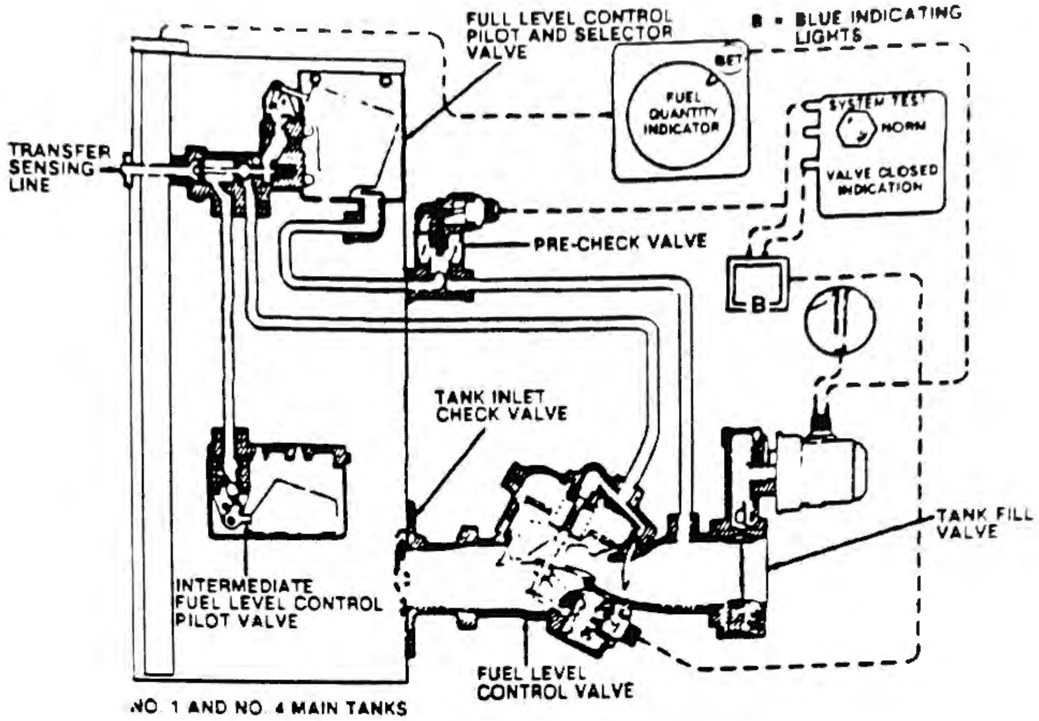
A. General

(1) The fuel tank fill system is comprised of typical tank subsystems consisting of components and controls that regulate tank filling (See Figures 28-65 and 28-66). Each tank subsystem consists basically of a tank fill (shutoff) valve, a fuel level control valve, a check valve, a precheck valve (for checking system operation). All tanks, except the outboard main tanks, have a fuel level control pilot valve installed. The outboard main tanks have fuel level control pilot and selector valves and intermediate fuel level control pilot valves installed. A line and a check valve are provided to bypass each outboard main tank selector valve to permit fuel to be transferred from the outboard main tanks to the corresponding outboard alternate tanks while still supplying fuel to the engine. Four pressure refueling adapters are installed in the wing leading edge.

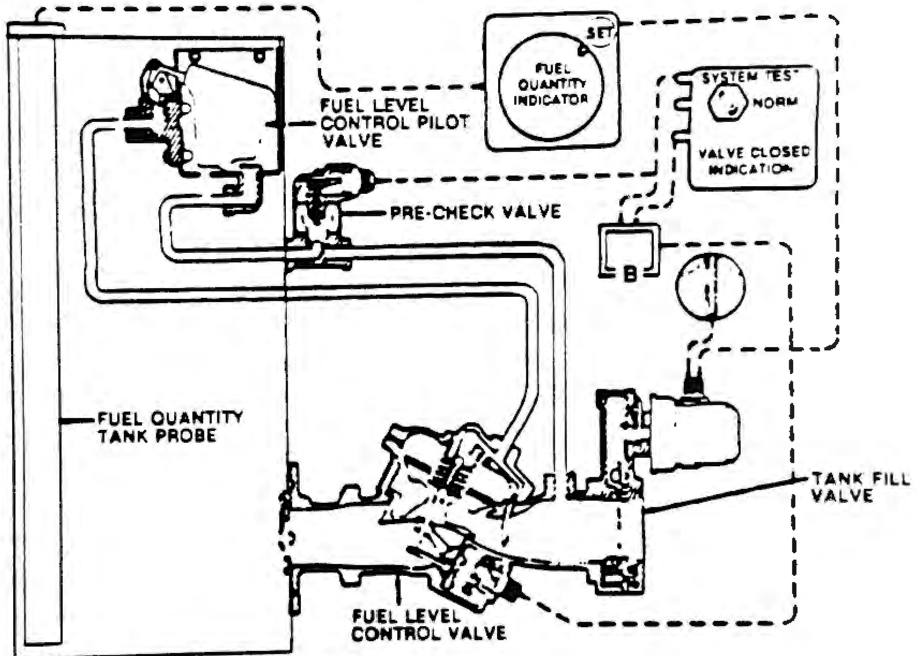
(2) The fill valve permits the fuel to flow into the tank from the crossfeed manifold and is used during refueling and fuel transfer. The main tank fill valve is controlled by a rotary switch. The alternate, the forward auxiliary, and the center wing tank-fill valves are controlled by toggle switches. Switches are located on the systems engineer's fuel panel in the flight compartment. Power is supplied to the switches from the 28 VDC bus. The fill valve operation is also controlled by a set switch in the fuel quantity indicator. The desired fuel quantity is selected and the set switch position is adjusted by a set knob on the indicator face. The selected fuel quantity is indicated by a pointer on the indicator dial periphery. The switch is in series electrically, with the fill valve control switch on the systems engineer's fuel panel and the fill valve motor.

(3) Surge protection relief valves are installed in parallel with the No. 1 and 4 alternate tank fill valves and fuel-level control valves. The surge protection relief valves relieve high surge pressures by allowing fuel flow into the No. 1 and 4 alternate tanks.

(4) The fuel level control valve is a pressure-operated, poppet-type valve used during refueling and fuel transfer to automatically stop fuel flow when the tank reaches the full level. It is controlled by two pressure-



NO. 1 AND NO. 4 MAIN TANKS

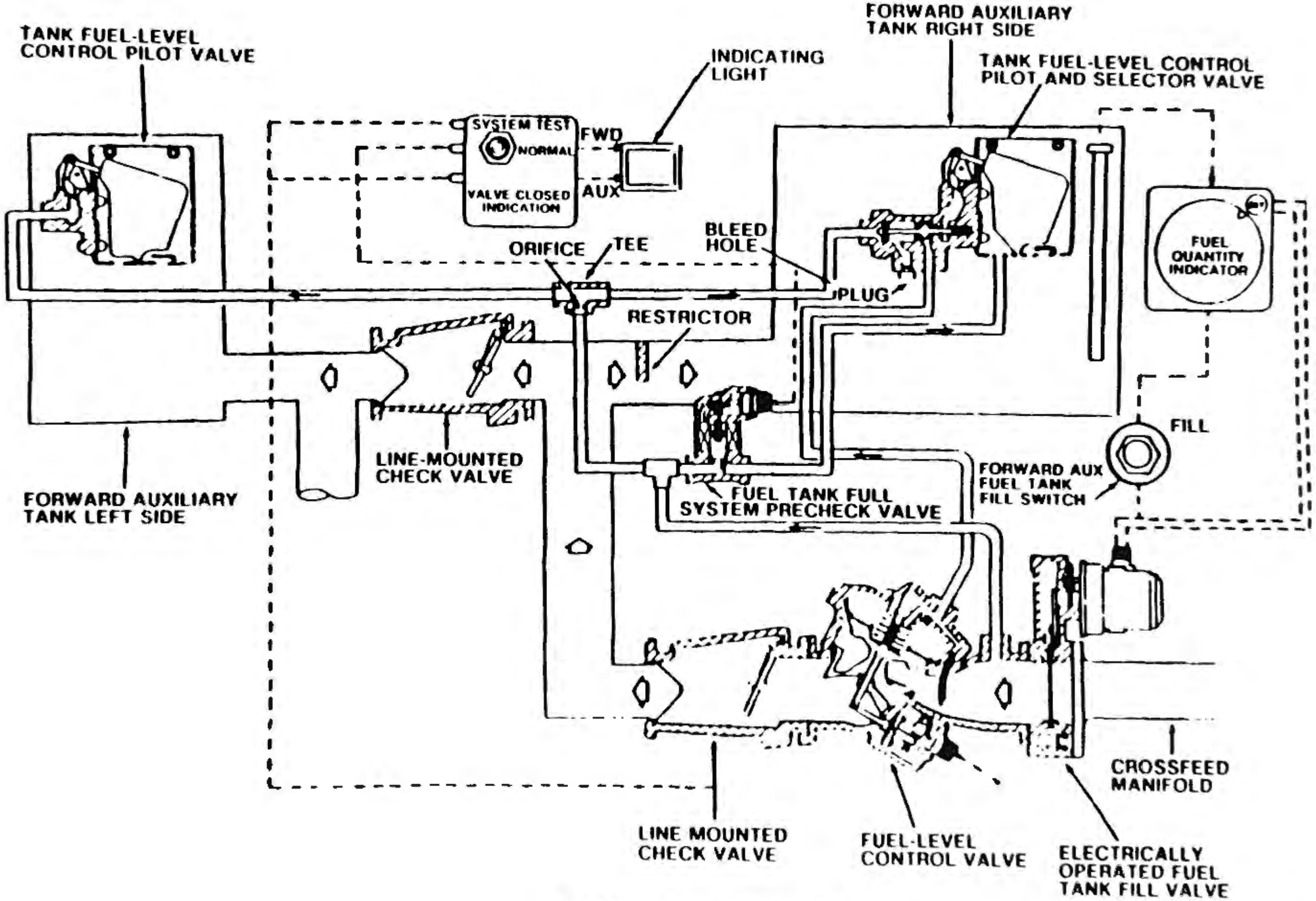


ALTERNATE TANKS, NO. 2 AND NO. 3 MAIN TANKS, AND CENTER WING TANK

TANK FILL SYSTEM

FTX80778

Figure 28-65


TANK FUEL-LEVEL CONTROL PILOT VALVE
SYSTEM TEST
NORMAL
VALVE CLOSED INDICATION
FWD
AUX
INDICATING LIGHT
FORWARD AUXILIARY TANK RIGHT SIDE
TANK FUEL-LEVEL CONTROL PILOT AND SELECTOR VALVE
FUEL QUANTITY INDICATOR
ORIFICE
TEE
BLEED HOLE
PLUG
RESTRICTOR
FILL
FORWARD AUX FUEL TANK FILL SWITCH
LINE-MOUNTED CHECK VALVE
FORWARD AUXILIARY TANK LEFT SIDE
FUEL TANK FULL SYSTEM PRECHECK VALVE
CROSSFEED MANIFOLD
LINE MOUNTED CHECK VALVE
FUEL-LEVEL CONTROL VALVE
ELECTRICALLY OPERATED FUEL TANK FILL VALVE

TANK FILL SYSTEM

FTX80779

Figure 28-66

sensing lines connected to the inlet side of the valve. An internal microswitch grounds the corresponding shut-off closed indicating light when the valve closes.

(5) A dual push-to-test light assembly, consisting of a light for the corresponding tank fuel level control valve, is located on the systems engineer's fuel control panel and indicates that the fuel level control valve is closed. Each light is placarded SHUT-OFF CLOSED, with its corresponding tank number included.

(6) The outboard alternate, inboard main, and center wing tanks have a fuel level control pilot valve connected by two lines, pilot and precheck, to the fuel level control valve. The pilot valve controls the pressure in the upper chamber of the control valve causing the control valve to open or close.

(7) The forward auxiliary tank has two pilot valves, a fuel-level control pilot valve located in the left side of the tank and a fuel-level control pilot and selector valve located in the right side of the tank. These two valves assure that the fuel-level control valve will shut-off regardless of which wing is low. A restrictor is provided in the inlet line of the right side of the tank to provide an equal fill rate for both sides. The fuel-level control valve is controlled by the right side pilot and selector valve. When the pilot and selector valve closes at the tank full level (right side low), and the tank full level is reached: the left side pilot valve closes, the selector valve in the pilot and selector valve actuates, and the fuel-level control valve closes. To accomplish this, the line connecting the two pilot valves is pressurized with fuel from the fuel-level control valve inlet. When the left side pilot valve closes, back pressure in the line connecting the two pilot valves actuates the selector valve in the pilot and selector valve. The actuated selector valve causes back pressure in the pilot line which closes the fuel-level control valve. An orifice is provided between the line connecting the pilot valves and the inlet to the fuel level control valve to reduce the pressure to that required for proper system operation. A bleed hole in the interconnecting line bleeds air from the line to assure that the right side pilot and selector valve will not operate due to only a static fuel head. A static fuel head could occur, for example, when the left wing is high. At this time the fuel and air contained in the line connecting the two pilot valves would pressurize the selector valve, if the entrapped air were not bled off.

(8) A precheck system valve in the precheck line is controlled by the fuel tank automatic shutoff system switch located on the systems engineer's fuel control panel in the flight compartment. This system simulates a full tank and checks the automatic shutoff function of the fuel level control valve. The tank fill system precheck valve is located in the wing leading edge.

(9) Each of the outboard main tanks has a fuel level control pilot and selector valve. These valves are similar to the other pilot valves, but have two additional sensing lines; a transfer-sensing line, which connects to the outlet of the corresponding alternate tank boost pump and an intermediate pilot line, which connects to the intermediate fuel level control pilot valve.

(10) The intermediate fuel level control pilot valve, located at approximately the 7000 pound fuel level in the tank, controls the position of the poppet in the fuel level control pilot and selector valve by controlling the pressure from the transfer-sensing line.

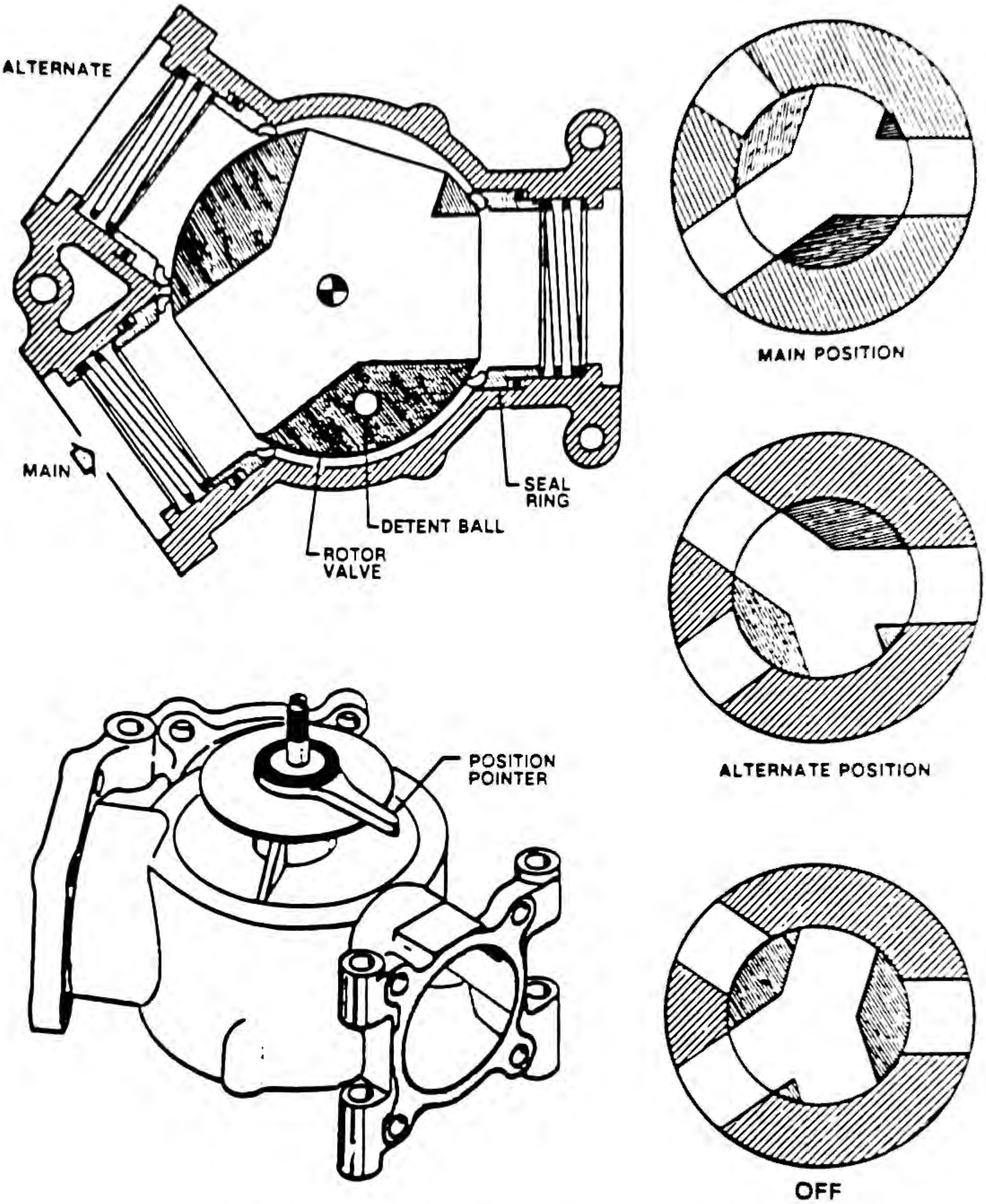
B. Description

(1) Intermediate Fuel Level Control Pilot Valve (See Figure 28-67)

(a) The intermediate fuel level control pilot valve is a float-operated needle-type valve positioned in the No. 1 and 4 main tanks to automatically control and maintain an intermediate fuel level.

(b) The valve assembly consists of a housing, a valve and float assembly, and metal can enclosure. The housing is plate-type, with a cutout center portion for venting the float chamber. Integral with the plate is a port for attaching a signal line from the fuel level control pilot and selector valve. A valve seat is threaded into the extended portion of the housing, under the inlet signal port. Two lugs, part of the housing, extend down to support the float assembly.

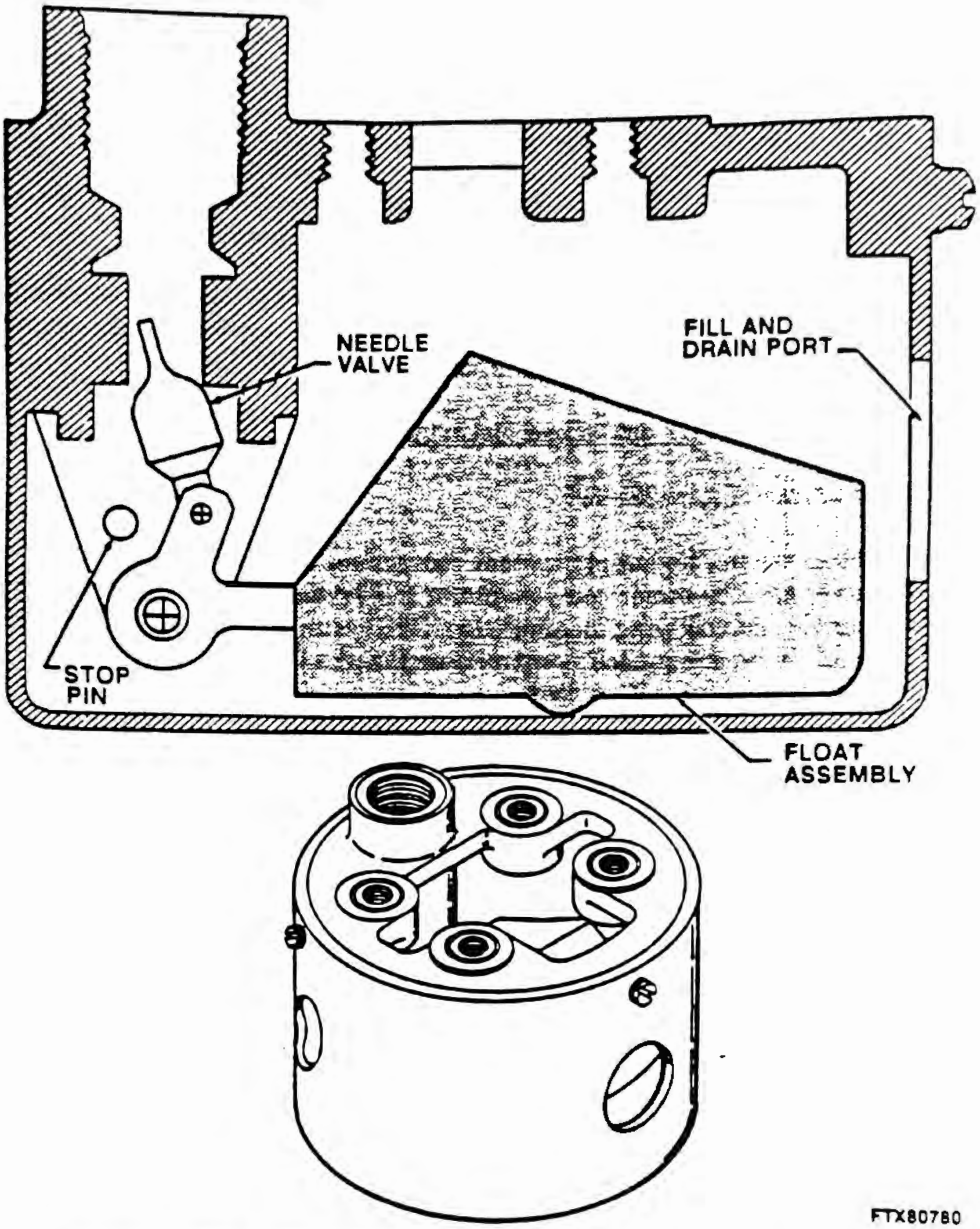
(c) The float assembly consists of a float, a float arm, and a needle valve. The valve attaches to the one end of the float arm and is self-aligning with the seat. The other end of the arm is secured in the float itself. A stop pin through the support lugs prevents the float from lifting and moving the arm past the valve-closed position. A protrusion on the valve prevents it from becoming



TANK SELECTOR VALVE - SCHEMATIC

FTX80782

Figure 28-69



INTERMEDIATE FUEL LEVEL CONTROL PILOT VALVE - SCHEMATIC

Figure 28-67

misaligned with the seating port by always remaining in it. A stop heel on the bottom of the float also aids in preventing the valve from being completely pulled down out of the port.

(d) The can, attached to the outer diameter of the housing plate, is approximately 2 inches high and 3 inches in diameter. The side periphery of the can has three 3/4-inch fill and drain holes to allow fuel to enter and drain from the float chamber.

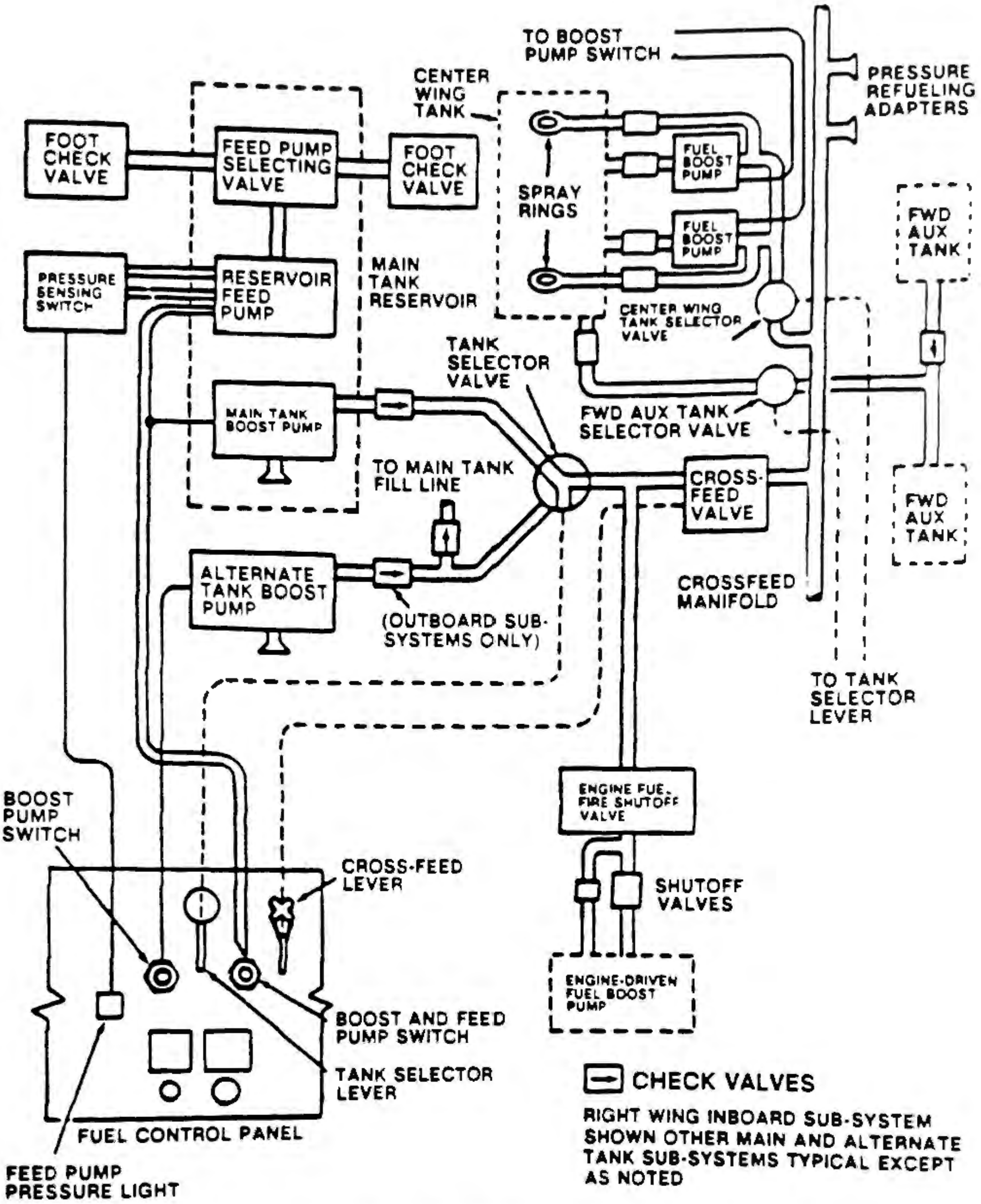
(e) The valve is held closed when the tank fuel level is higher than the valve. When the fuel level lowers to the valve level, the float drops with the fuel level and opens the needle valve.

7. Engine Fuel Supply System - Description And Operation

A. General (See Figure 28-68)

(1) The engine fuel supply system routes fuel from the tanks to the engines. The major components of the system are located in the fuel tanks and the wing leading edge. The system controls are located on the systems engineer's control panel in the flight compartment. The engine fuel supply system is made up of independent subsystems. By use of a crossfeed system, an independent system can supply fuel to any or all of the other independent systems. The supply system includes the tank fuel boost pumps, tank selector valves, crossfeed valves, crossfeed manifold drain valve, engine fuel fire shutoff valves, line-mounted check valves, fuel inlet supply shutoff valves, fuel vapor removal shutoff valves, and the necessary connecting fuel lines.

(2) Each main tank is provided with an integral reservoir to ensure that the main tank boost pump, which is mounted in the bottom of the reservoir, will be submerged when the airplane is in extreme attitudes, or accelerating, or when the fuel level is low. Fuel is supplied to the reservoir either through 1-way flapper check valves in the reservoir sides or by a feed pump located in the reservoir. Fuel to the feed pump is supplied through either of two foot check valves and an inlet selecting valve. The feed pump and boost pump are controlled by a common 3-position switch located on the systems engineer's control panel. The main and alternate tank selector valve permits either the main or the alternate tank to supply fuel to the system. The center wing tank and the forward auxiliary tank valves are manually operated gate valves that open or close the respective tank discharge



RIGHT WING INBOARD SUB-SYSTEM SHOWN OTHER MAIN AND ALTERNATE TANK SUB-SYSTEMS TYPICAL EXCEPT AS NOTED

ENGINE FUEL SUPPLY SYSTEM - FUNCTIONAL SCHEMATIC

FTX80781

Figure 28-68

lines. The center tank line discharges fuel into the supply system. The forward auxiliary tank line discharges fuel into the center tank. The selector valve is controlled by a lever on the systems engineer's control panel through cables and mechanical linkage. Downstream of the tank selector valve is the crossfeed valve and the engine fuel fire shutoff valve, which are 2-position, mechanically operated valves. The crossfeed valves are operated by levers on the systems engineer's control panel through cables and mechanical linkage. The engine fuel fire shutoff valve is operated through cable and mechanical linkage by the fire control handle located in the overhead panel in the flight compartment. Downstream of the fire shutoff valve is the fuel shutoff valve and the vapor shutoff valve used to close the lines to the engine during engine (or engine fuel component) removal. These valves are manually operated by handles on the valve. The valves are located on pylon firewall near the pylon disconnect box. A line is also installed to permit transfer of fuel from the No. 1 and No. 4 main tanks to the corresponding alternate tank without utilizing the crossfeed system. This transfer may be accomplished while supplying fuel to the corresponding engine.

B. Description

(1) Tank Selector Valve (See Figure 28-69)

(a) The main and alternate tank selector valve is a 3-port cable-operated valve. The valve can be positioned to route fuel either from a main or alternate tank directly to its respective engine. It also can be positioned to shut off all fuel supply from the respective engine. It also can be positioned to shut off all fuel supply from the respective main alternate tanks. The valve consists of a housing, a 3-port rotor valve assembly, a spring- loaded seal ring in each of the three housing ports, and a detent plate.

(b) The spring-loaded seal rings in the housing ports are held in constant contact to the valve rotor. As the valve is rotated to a detent position where one or two of the valve ports align with the ports in the housing, the seal rings seat and seal the mating ports. Two of the positions of the selector valve align either one of the inlets with the outlet port. In either of these positions, the pointer of the coupling indicates which inlet is open to the outlet. The other position closes off both inlets to the valve outlet and is indicated by the position of the pointer between the outlet and one of the inlet ports. The center wing tank selector valve and the forward auxiliary tank selector valve are manually operated gate type valves. The center tank valve is identical to the crossfeed valve. The forward auxiliary tank valve is similar in construction and operation.

(2) Fuel Inlet Supply Shutoff Valve (See Figure 28-70)

(a) The fuel inlet supply shutoff valves are manually operated gate-type valves. There is one valve in each engine fuel supply line. The valve is installed on the right side of the pylon firewall at the pylon disconnect box, and is covered by a sheet metal guard which is placarded OPEN and CLOSED.

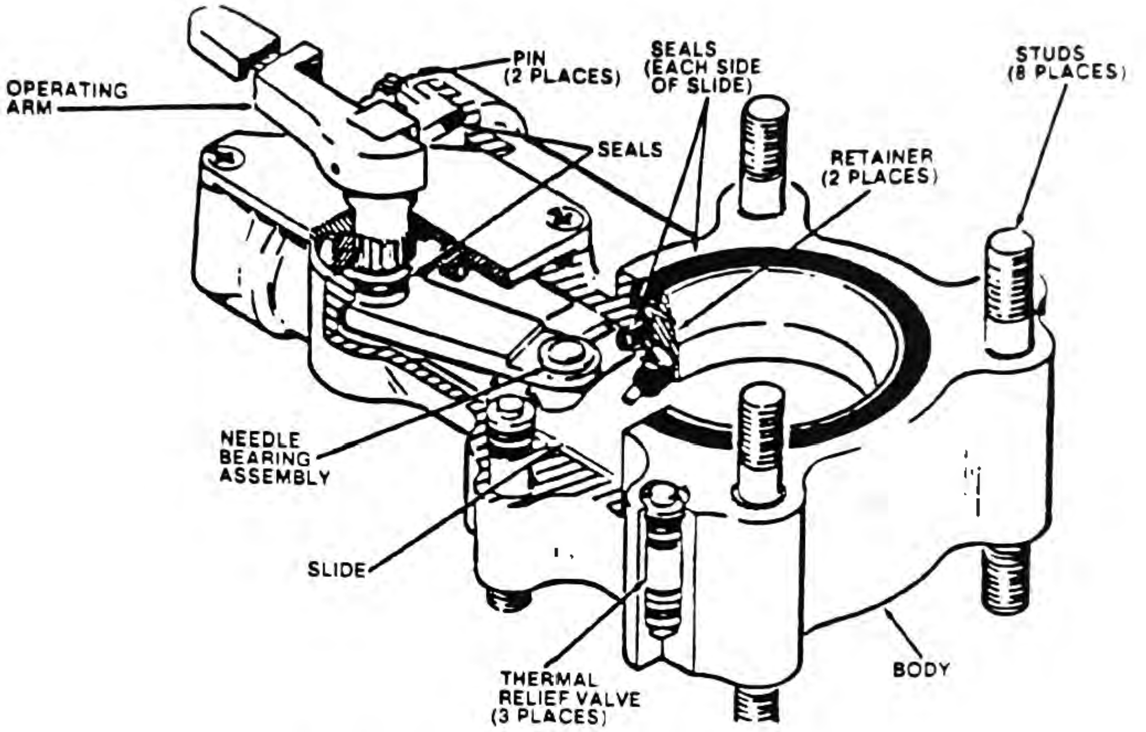
(b) The valve assembly within the valve body consists of a slide with a slot in the upper end which receives the roller on the operating arm assembly. Rotating the arm 90 degrees to the closed position moves the slide down into the lower portion of the valve body between two spring-loaded seals. This action shuts off the fuel supply to the engine fuel system.

(c) Two Line relief valves, operating in opposite directions, and a body relief valve are provided to relieve excessive pressure buildup due to the expansion of trapped fuel. The line relief valves open at 22 to 32 psi. The body relief valve opens at 105 to 135 psi.

(3) Fuel Vapor Removal Shutoff Valve (See Figure 28-71)

(a) The fuel vapor removal shutoff valve is a manually operated ported ball-type valve. There is one valve installed in each fuel vapor vent removal line on the right side of the pylon firewall at the pylon disconnect box.

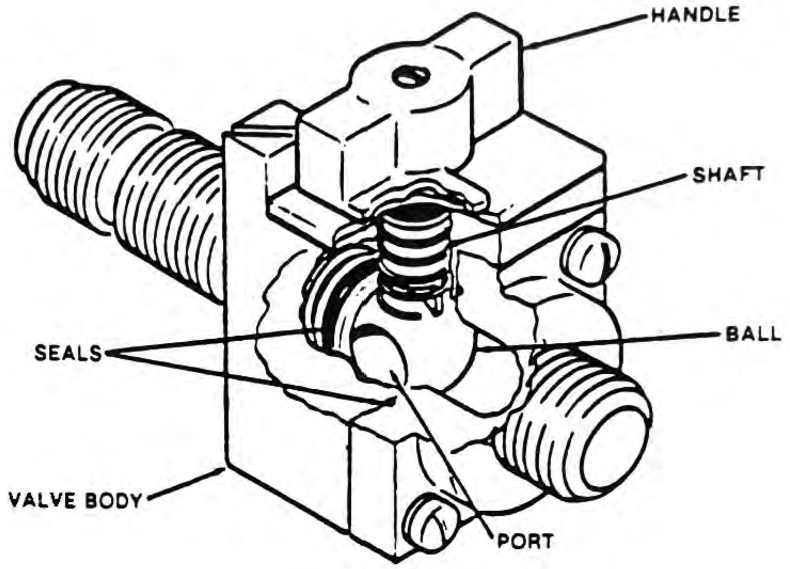
(b) The valve consists of a valve body, a handle and shaft assembly, a ported ball, and a seal assembly which is spring loaded to bear against the ball on the inlet side.



FUEL INLET SUPPLY SHUTOFF VALVE

FTX80783

Figure 28-70



FUEL VAPOR REMOVAL SHUTOFF VALVE

FTX80788

Figure 28-71

(c) Rotation of the handle through 90 degrees, against a stop, opens or closes the valve. Ball detents in the handle assembly provide a "feel" for open and closed positions during operation and serve to maintain the valve position. In the closed position, the valve prevents the spillage of any fuel present in the pylon fuel vapor vent during engine removal.

8. Fuel Low Level Indicating Light System - Description And Operation

A. General

Two identical fuel quantity low level indicating light systems are installed, one in the No. 1 main and alternate tanks and one in the No. 4 main and alternate tanks. Power for the system is supplied from a 28 VDC bus through a circuit breaker located in the fuel management and engine section of the electrical power center circuit breaker panel.

B. Description

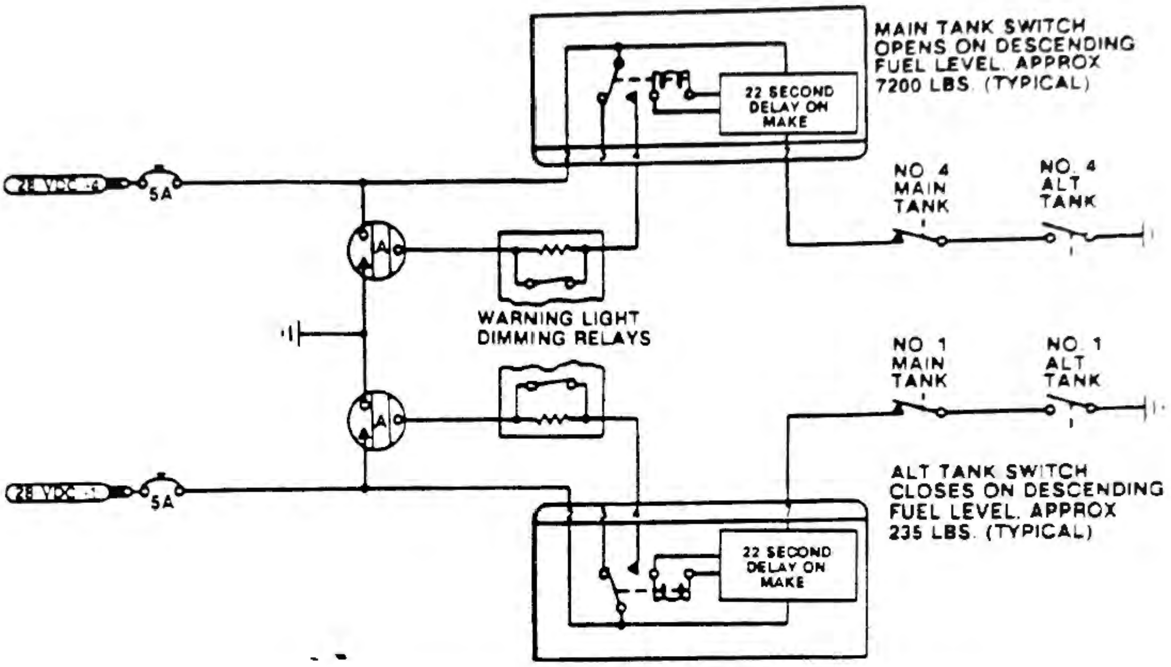
(1) Each system consists of two fuel level float switches connected in series, a time delay relay, an indicating light dimming relay, and an amber press-to-test indicating light located on the right side of the engineers fuel panel.

(2) The fuel quantity low level indicating light switches are float-operated magnetic switches. The switch assembly consists of a hermetically sealed glass enclosed switch, two float supported magnets, and a perforated aluminum shell.

C. Operation (See Figures 28-72 and 28-73)

(1) Vertical movement of the float as a result of the rise or fall of the fuel surrounding the switch assembly causes the switch to make or break contact as applicable. The float switch located in the alternate tank is open when the fuel level is at or above the operating level of the switch. Conversely, the switch located in the main tank is closed when immersed.

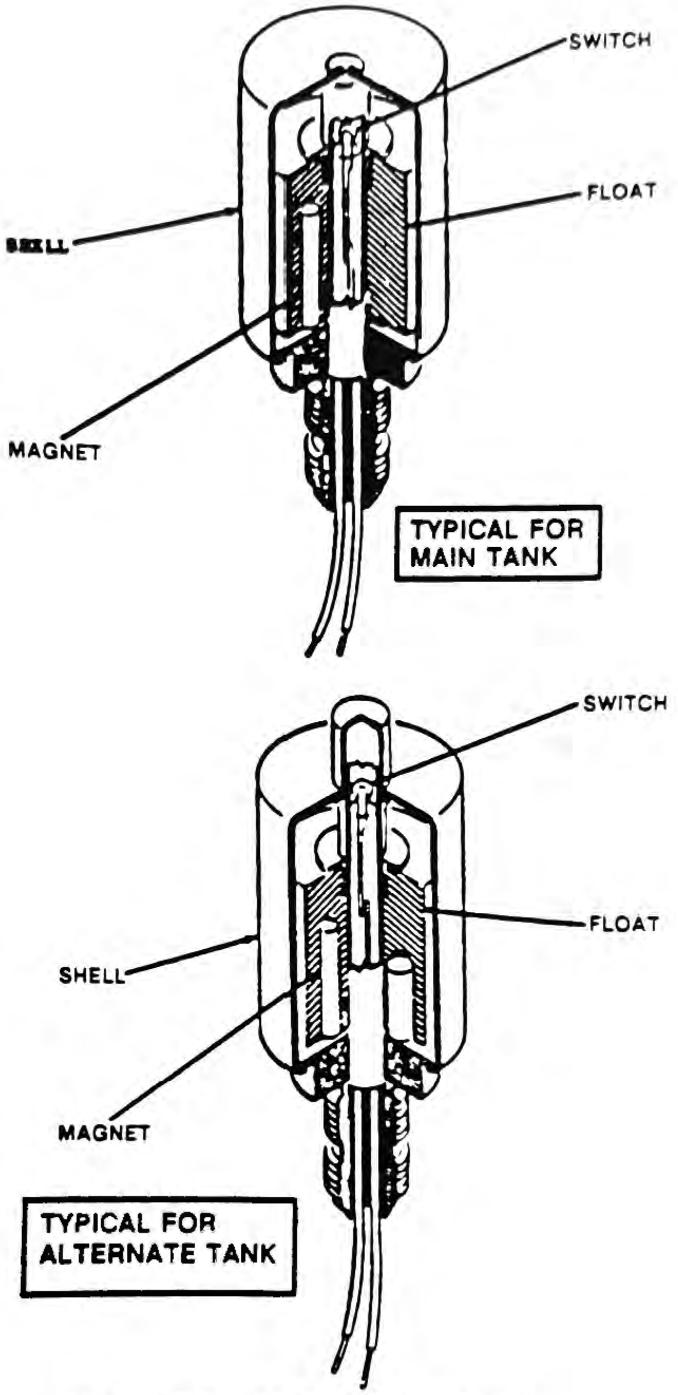
(2) If the fuel level in an alternate tank falls below the full level when the corresponding main tank contains 7500 pounds or more of fuel, the switches will be in the closed position, completing the circuit and causing the light to come on.


MAIN TANK SWITCH OPENS ON DESCENDING FUEL LEVEL. APPROX 7200 LBS. (TYPICAL)
22 SECOND DELAY ON MAKE
5A
NO. 4 MAIN TANK
NO. 4 ALT TANK
A
WARNING LIGHT DIMMING RELAYS
NO. 1 MAIN TANK
NO. 1 ALT TANK
A
5A
ALT TANK SWITCH CLOSES ON DESCENDING FUEL LEVEL. APPROX 235 LBS. (TYPICAL)
22 SECOND DELAY ON MAKE

FUEL LOW LEVEL INDICATING LIGHT SYSTEM

FTX80784

Figure 28-72



FUEL LOW LEVEL INDICATING LIGHT FLOAT SWITCH FTX80785

Figure 28-73

TOTAL FUEL LOAD	1 & 4 ALT				1 & 4 MAIN		2 & 3 ALT		2 & 3 MAIN		CW AUX		FWD AUX		
	LBS	STICK											LBS	STICK	
		INB	OTB	TIP	LBS	STK	LBS	STICK FWD	LBS	STK	LBS	STK		INB	OTB
30,000	500				● 7,000	2 1/4			7,500	11 1/2					
33,000	1,250	1			● 7,000	2 1/4			8,250	13					
35,000	1,750	2 3/4			● 7,000	2 1/4			8,750	14 1/4					
40,000	3,000	6 1/2			● 7,000	2 1/4			10,000	17					
45,000	4,250	9 1/2			● 7,000	2 1/4			11,250	19 3/4					
50,000	5,500	12 1/2			● 7,000	2 1/4			12,500	22 3/4					
52,000	6,000	13 1/2			● 7,000	2 1/4			13,000	23 3/4					
53,000	6,250		1 1/4		● 7,000	2 1/4			13,250	24 1/4					
55,000	6,750		2 1/2		● 7,000	2 1/4			13,750	25 1/2					
60,000	8,000		6 1/4		● 7,000	2 1/4			15,000	28 1/2					
64,000	9,000		9 1/2		● 7,000	2 1/4			16,000	31 1/4					
65,000	9,250			1	● 7,000	2 1/4			16,250	32					
69,000	10,250			5 1/2	● 7,000	2 1/4			17,250	35 3/4					
70,000	10,320			6	7,180	2 1/2	●● 3,500	6 1/2	14,000	26					
75,000	FULL			FULL	8,430	4 1/2	●● 3,500	6 1/2	15,250	29 1/4					
80,000					9,680	6 1/2	●● 3,500	6 1/2	16,500	33					
84,000					10,680	7 3/4	3,650	7	17,350	36					
85,000					10,930	8 1/4	3,900	7 1/2	FULL	FULL					
90,000					12,180	9 3/4	5,150	11							
95,000					13,430	11 1/2	6,400	14 1/2							
100,000					14,680	13 1/4	7,650	18							
105,000					15,930	15	8,900	21							
110,000					17,180	16 3/4	10,150	24 1/2							
115,000					18,430	19 1/4	11,400	28 3/4							
119,000					19,460	22	12,370	33							
120,000-8	(10,320)			(6)	(19,940)	(23)	(12,370)	(33)	(17,350)	(36)					
121,000					FULL	FULL	FULL	FULL			1,040	1 3/4			
125,000											5,040	8 1/2			
130,000											10,040	15 3/4			
135,000											15,040	22 3/4			
140,000											20,040	30			
145,000											25,040	37 1/4			
147,000											27,040	41			
148,000-9	(10,320)			(6)	(19,940)	(23)	(12,370)	(33)	(17,350)	(36)	(27,890)	(43 1/2)	150	1 1/4	
150,000											FULL	FULL	2,150	13	
154,000													6,150	1/4	
155,00													7,150		10 1/2
156,730-10	10,320			6	19,940	23	12,370	33	17,350	36	27,890	43 1/2	8,880		17 1/2

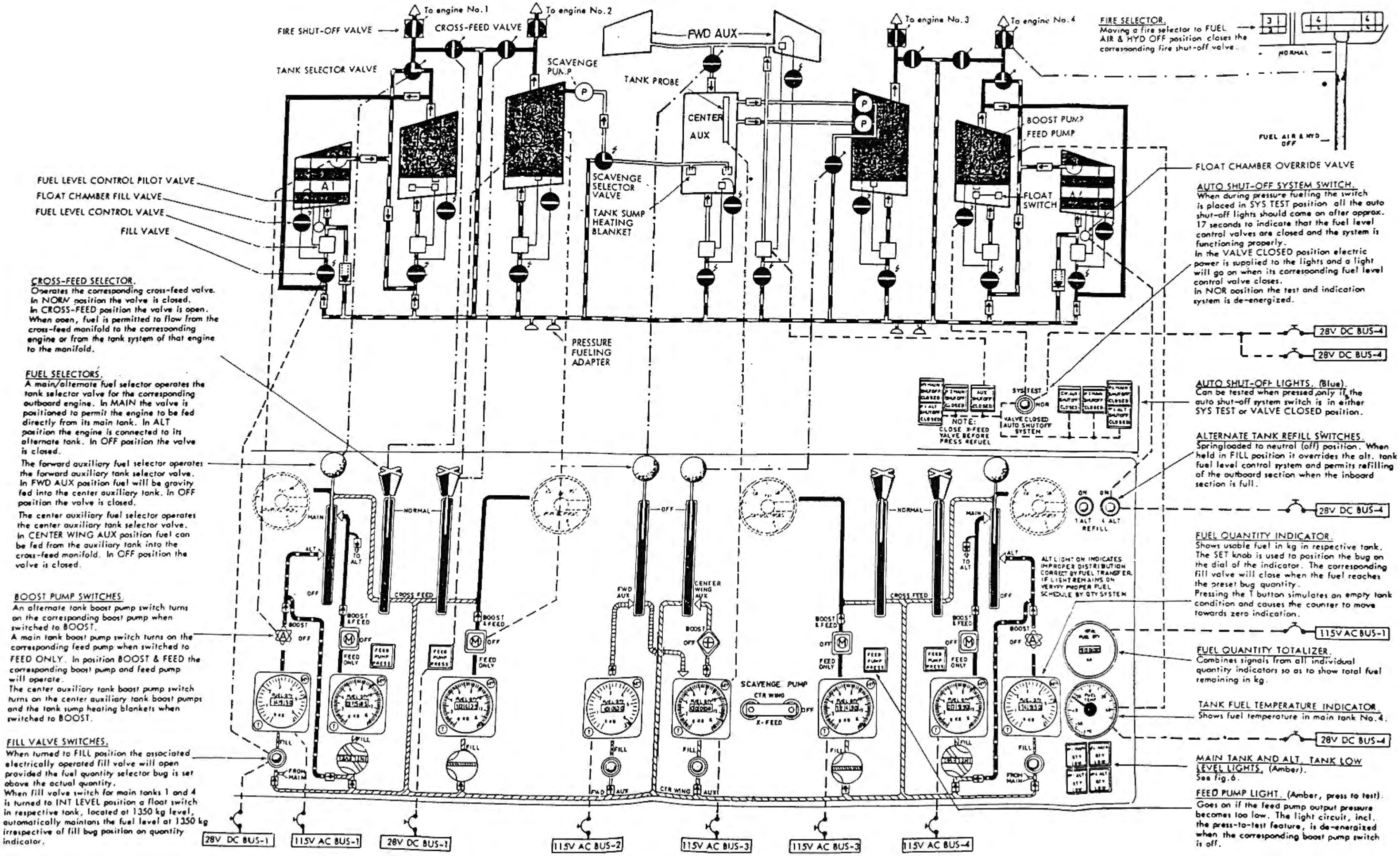
-8 TANK TOTAL = (119,960 LBS)
-9 TANK TOTAL = (147,850 LBS)
-10 TANK TOTAL = (156,730 LBS)
● FUEL LEVEL IN NO. 1 AND 4 MAIN SHOULD BE MAINTAINED AT 7,000 LBS UNTIL NO. 1 AND 4 ALTERNATE TANKS ARE FULL.
●● FUEL LEVEL IN NO. 2 AND 3 ALTERNATE TANKS SHOULD BE MAINTAINED AT 3,500 LBS UNTIL NO. 2 AND 3 MAIN TANKS ARE FULL.

FUEL QUANTITY DISTRIBUTION DC8-61

FTX80787

Figure 28-74

FUEL SYSTEM
Description



ALT LIGHT ON INDICATES IMPROPER DISTRIBUTION CORRECT BY FUEL TRANSFER. IF LIGHT REMAINS ON VERYFY PROPER FUEL SCHEDULE BY QTY SYSTEM

CROSS-FEED SELECTOR.
Operates the corresponding cross-feed valve.
In NORM position the valve is closed.
In CROSS-FEED position the valve is open.
When open, fuel is permitted to flow from the cross-feed manifold to the corresponding engine or from the tank system of that engine to the manifold.

FUEL SELECTORS.
A main/alternate fuel selector operates the tank selector valve for the corresponding outboard engine. In MAIN the valve is positioned to permit the engine to be fed directly from its main tank. In ALT position the engine is connected to its alternate tank. In OFF position the valve is closed.

The forward auxiliary fuel selector operates the forward auxiliary tank selector valve. In FWD AUX position fuel will be gravity fed into the center auxiliary tank. In OFF position the valve is closed.

The center auxiliary fuel selector operates the center auxiliary tank selector valve. In CENTER WING AUX position fuel can be fed from the auxiliary tank into the cross-feed manifold. In OFF position the valve is closed.

BOOST PUMP SWITCHES.
An alternate tank boost pump switch turns on the corresponding boost pump when switched to BOOST.
A main tank boost pump switch turns on the corresponding feed pump when switched to FEED ONLY. In position BOOST & FEED the corresponding boost pump and feed pump will operate.
The center auxiliary tank boost pump switch turns on the center auxiliary tank boost pumps and the tank sump heating blankets when switched to BOOST.

FILL VALVE SWITCHES.
When turned to FILL position the associated electrically operated fill valve will open provided the fuel quantity selector bug is set above the actual quantity.
When fill valve switch for main tanks 1 and 4 is turned to INT LEVEL position a float switch in respective tank, located at 1350 kg level, automatically maintains the fuel level at 1350 kg irrespective of fill bug position on quantity indicator.

FIRE SELECTOR.
Moving a fire selector to FUEL AIR & HYD OFF position closes the corresponding fire shut-off valve.

AUTO SHUT-OFF SYSTEM SWITCH.
When during pressure fueling the switch is placed in SYS TEST position all the auto shut-off lights should come on after approx. 17 seconds to indicate that the fuel level control valves are closed and the system is functioning properly.
In the VALVE CLOSED position electric power is supplied to the lights and a light will go on when its corresponding fuel level control valve closes.
In NOR position the test and indication system is de-energized.

AUTO SHUT-OFF LIGHTS. (Blue).
Can be tested when pressed only if the auto shut-off system switch is in either SYS TEST or VALVE CLOSED position.

ALTERNATE TANK REFILL SWITCHES.
Springloaded to neutral (off) position. When held in FILL position it overrides the alt. tank fuel level control system and permits refilling of the outboard section when the inboard section is full.

FUEL QUANTITY INDICATOR.
Shows usable fuel in kg in respective tank. The SET knob is used to position the bug on the dial of the indicator. The corresponding fill valve will close when the fuel reaches the preset bug quantity.
Pressing the T button simulates an empty tank condition and causes the counter to move towards zero indication.

FUEL QUANTITY TOTALIZER.
Combines signals from all individual quantity indicators so as to show total fuel remaining in kg.

TANK FUEL TEMPERATURE INDICATOR.
Shows fuel temperature in main tank No.4.

MAIN TANK AND ALT. TANK LOW LEVEL LIGHTS. (Amber).
See fig.6.

FEED PUMP LIGHT. (Amber, press to test).
Goes on if the feed pump output pressure becomes too low. The light circuit, incl. the press-to-test feature, is de-energized when the corresponding boost pump switch is off.

1. General - Description and Operation

A. Description (See Figures 30-1 & 30-2)

(1) Ice protection is provided by a deicing system to remove accumulated ice, and by anti-icing systems to prevent the formation of ice. The leading edges of the wings, including the wing leading edge slots, and the horizontal stabilizer are deiced. The fuselage nose scoops are anti-iced. Hot air for deicing and anti-icing is supplied from the low-pressure pneumatic system. Electrical anti-icing systems are provided for the windshields, stall warning lift transducer, pitot tubes, and water basin drain masts.

(2) The controls and indicating lights for the deicing system are grouped on the systems engineer's control panel. The pneumatic and electrical anti-icing systems are controlled and monitored from the overhead switch panel.

(3) The airfoil deicing system is set in operation by placing the airfoil deicing switch in either the timer 1 or timer 2 position.

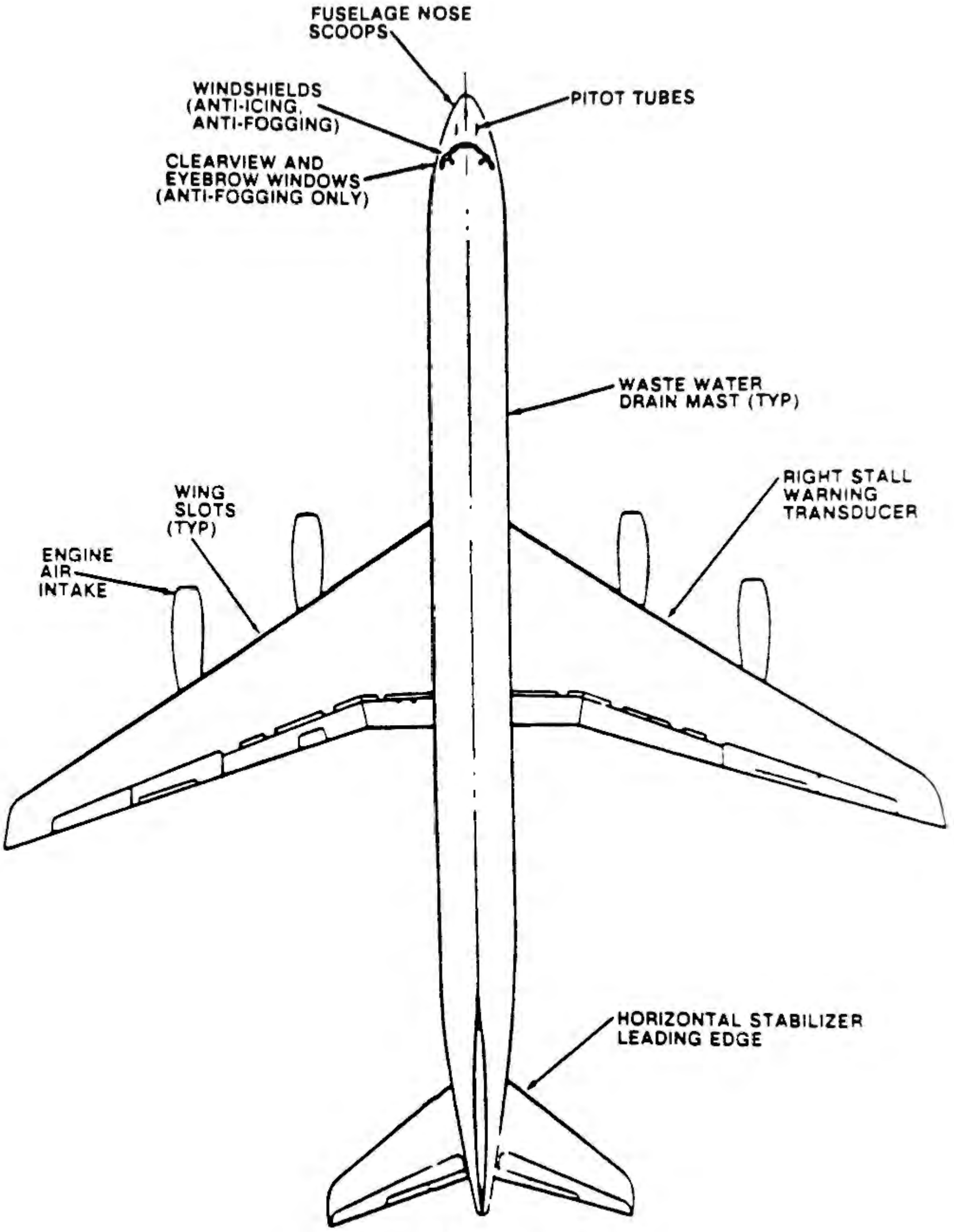
(4) The scoops anti-icing system is operated from the overhead switch panel by placing the control switch in the anti-ice position.

(5) The anti-icing heaters and ammeter selector switch, when placed in one of the operating positions, energizes all pitot and static port heaters and the heaters in the stall warning lift transducers.

(6) The windshield and window heat control system is controlled by the windshield heat control switch located on the overhead switch panel.

(7) Air from the pneumatic system is used for windshield rain removal. The flow of air is controlled by cable-actuated valves, operated by levers located in the captain's and first officer's consoles.

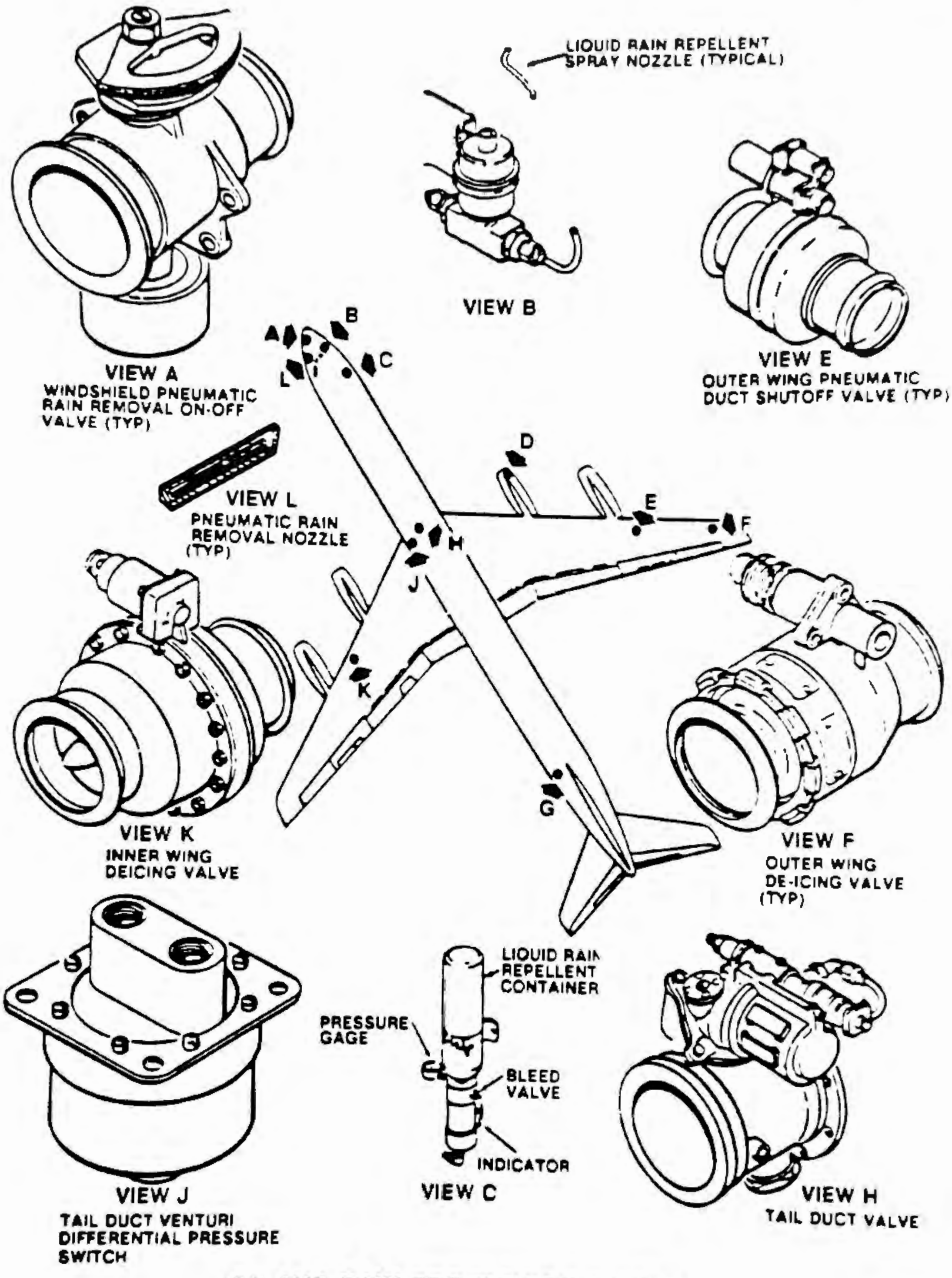
(8) A liquid rain rèpellent system facilitates the removal of rain from the windshields. The system is controlled by momentary pushbuttons located on the flight compartment glareshield. The repellent is stored in a pressurized container located on the outside of the first officer's console.


FUSELAGE NOSE SCOOPS
WINDSHIELDS (ANTI-ICING, ANTI-FOGGING)
PITOT TUBES
CLEARVIEW AND EYEBROW WINDOWS (ANTI-FOGGING ONLY)
WASTE WATER DRAIN MAST (TYP)
RIGHT STALL WARNING TRANSDUCER
WING SLOTS (TYP)
ENGINE AIR INTAKE
HORIZONTAL STABILIZER LEADING EDGE

ICE PROTECTION AREAS

FTX80508

Figure 30-1


LIQUID RAIN REPELLENT SPRAY NOZZLE (TYPICAL)
VIEW B
VIEW A
WINDSHIELD PNEUMATIC RAIN REMOVAL ON-OFF VALVE (TYP)
VIEW E
OUTER WING PNEUMATIC DUCT SHUTOFF VALVE (TYP)
A
B
C
L
I
D
E
F
H
J
K
G
VIEW L
PNEUMATIC RAIN REMOVAL NOZZLE (TYP)
VIEW K
INNER WING DEICING VALVE
VIEW F
OUTER WING DE-ICING VALVE (TYP)
LIQUID RAIN REPELLENT CONTAINER
PRESSURE GAGE
BLEED VALVE
INDICATOR
VIEW J
TAIL DUCT VENTURI DIFFERENTIAL PRESSURE SWITCH
VIEW C
VIEW H
TAIL DUCT VALVE

ICE AND RAIN PROTECTION SYSTEM

FTX80509

Figure 30-2

2. Airfoil - Description and Operation

A. General (See Figure 30-3)

(1) The airfoil deicing system removes ice from the leading edges of the wing, the leading edges of the wing slots, the wing slots lower doors, and the leading edges of the horizontal stabilizer. Hot air from the low-pressure pneumatic system is distributed to the leading edges through a system of ducts and by electrically controlled, pneumatically operated valves.

(2) Fourteen deicing valves, 12 of which are operated in pairs by either one of two timers, permit intermittent airflow to the deicing segments.

(3) An interlock wing slot deice relay is actuated when the landing gear control lever is placed in the down position. This permits a triple-cycle feature to deice the slotted wing sections approximately three times as often as the wing sections without slots.

(4) Controls for the system are located on the system engineer's control panel. They include the airfoil deicing switch, two identical timers, a guarded tail duct valve switch, tail deice pushbutton, and a tail deicing system indicating light. The system is electrically interlocked with the ground control relay circuit so that the deicing valves cannot be operated on the ground.

(5) The deicing timer motors, the tail duct valve, and the outer wing pneumatic duct shutoff valves are independent of the ground control relay.

(6) Air directed to the center and inner wing leading edges (inboard of No. 1 and 4 pylons) is supplied directly by the pneumatic manifold. From the low-pressure pneumatic manifold, air is directed to the left and right outer wings (outboard of No. 1 and 4 pylons) through the outer wing pneumatic duct shutoff valves, and to the empennage through the tail duct valve and the tail duct. The tail duct extends from the tail duct valve in the fuselage to the tail section of the airplane. This duct is located on the left side of the fuselage below the floor, in the pressurized area, and extends into the horizontal stabilizer. D-ducts in the leading edge of each airfoil are divided into a total of 18 sections and direct the distribution of air through the leading edge areas to be deiced. All D-ducts are riveted to ribs located in the

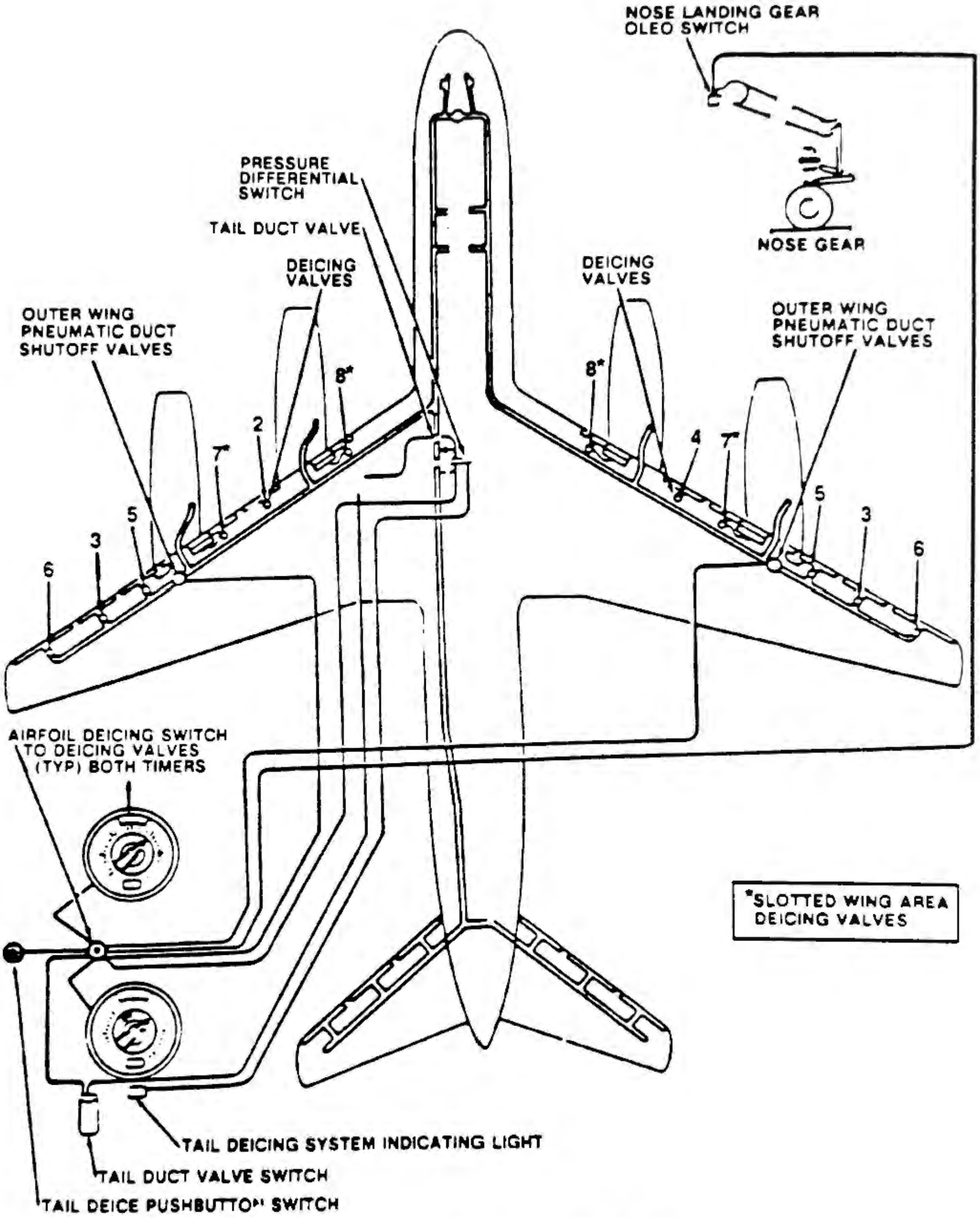
wing and stabilizer leading edges, and are removed and installed as integral components of the leading edge structure. The deicing air exhausts overboard from the wing leading edges through slots in the lower surface between pylons. Air from the horizontal stabilizer leading edges exhausts into the tail cone and overboard through slots in the tail cone, the elevator torque tube, and the horizontal stabilizer torque box.

(7) V-band clamps and flexible connectors connect the tail duct sections. The flexible connectors in the pressurized area are a double-walled type, similar to the connectors used in the pneumatic manifold with the exception of the attaching flanges. The connectors in the nonpressurized area (tail section) are a single-walled type attached to the beaded ends of the duct with clamps.

(8) The tail duct directs air to the horizontal stabilizer. A Y- duct in the horizontal stabilizer with a flexible connector located at the pivot of the stabilizer allows the duct to flex with stabilizer movement. The ducts in the stabilizer leading edge have three deicing ports on each side of the stabilizer. A bleed orifice is located near the outboard end of the ducts. Air from the tail duct bleeds into the leading edge area from these orifices, ensuring a hot air supply to all tail deicing flow-limiting orifices when the tail duct valve is open.

(9) A flow-limiting venturi, located just downstream of the tail duct valve, provides a pressure signal for the tail duct valve differential-pressure switch. Two sensing lines are connected across the venturi, one at the throat and one immediately upstream of the venturi.

(10) The outer wing ducts extend from the outer wing pneumatic duct shutoff valves, connected to the pneumatic manifold (outboard of No. 1 and 4 pylons), to the wing tips. An anti- icing air outlet is located near the outboard end of each duct. The two ducts are composed of sections connected with clamps and single-wall flexible connectors. Each section is supported by a fixed and slip-type bracket. The fixed bracket holds the duct section rigid where the deicing valves attach to the deicing air outlets. The slip supports allow the duct to expand and contract, and also allow for structural deflections.


NOSE LANDING GEAR OLEO SWITCH
NOSE GEAR
PRESSURE DIFFERENTIAL SWITCH
TAIL DUCT VALVE
DEICING VALVES
DEICING VALVES
OUTER WING PNEUMATIC DUCT SHUTOFF VALVES
OUTER WING PNEUMATIC DUCT SHUTOFF VALVES
8*
8*
2
4
7*
7*
5
5
3
3
6
6
AIRFOIL DEICING SWITCH TO DEICING VALVES (TYP) BOTH TIMERS
*SLOTTED WING AREA DEICING VALVES
TAIL DEICING SYSTEM INDICATING LIGHT
TAIL DUCT VALVE SWITCH
TAIL DEICE PUSHBUTTON SWITCH

AIRFOIL DEICING SYSTEM

FTX80510

Figure 30-3

(11) The airfoil deicing controls and indicating light system provides for electrical control and monitoring of the deicing of the wing and tail surfaces. The system controls and indicating light are located on the systems engineer's control panel and include the following:

(a) Airfoil deicing switch, with timer 1--off--timer 2 positions

(b) Two airfoil timers (these also act as cycle sequence indicators for wing deicing valves)

(c) Tail deicing pushbutton (to cycle tail duct valve for 150 seconds)

(d) Tail deicing system indicating light

(e) Tail duct valve switch, with normal--off positions.

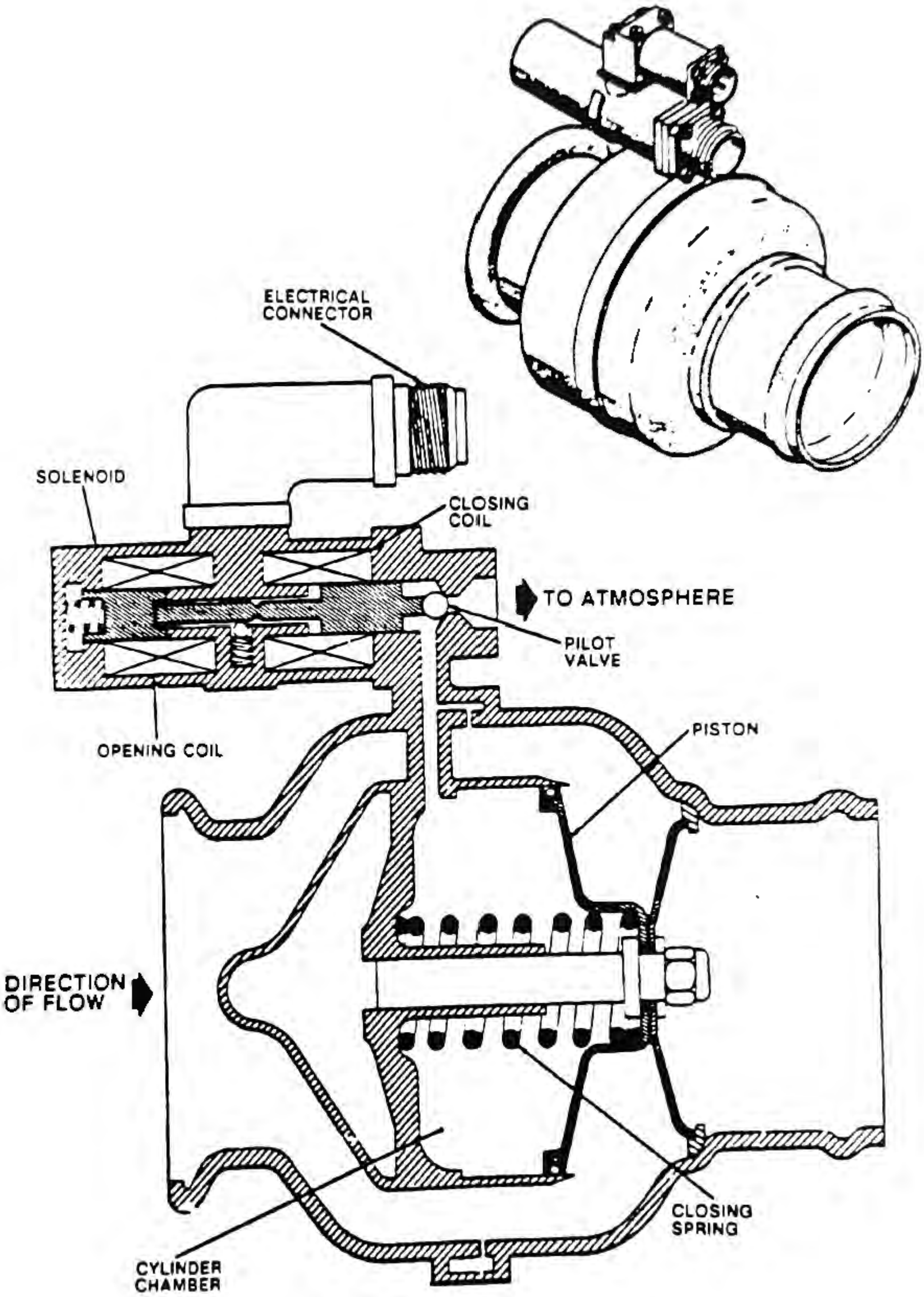
B. Component Description

(1) Outer Wing Pneumatic Duct Shutoff Valve (See Figure 30-4)

(a) An outer wing pneumatic duct shutoff valve is installed between the low-pressure pneumatic manifold and the outer wing pneumatic duct.

(b) It is an electrically controlled, pneumatically actuated, poppet-type valve. The valve operates when the pneumatic manifold is pressurized and electrical power is directed to the valve by either the airfoil deicing system or the anti- icing system.

(c) When electrical power is supplied to the open winding of the valve solenoid by one of the above systems, air pressure from the pneumatic system opens the valve. As long a pneumatic power is supplied, the valve remains open until the close winding of the valve solenoid is energized. When the valve opens, air from the pneumatic system is directed to the outer wing pneumatic duct. The duct supplies air to the outer wing deicing valves and to the outer wing vent scoop.



OUTER WING PNEUMATIC DUCT SHUTOFF VALVE

FTX80511

Figure 30-4

(2) Tail Duct Valve (See Figure 30-5)

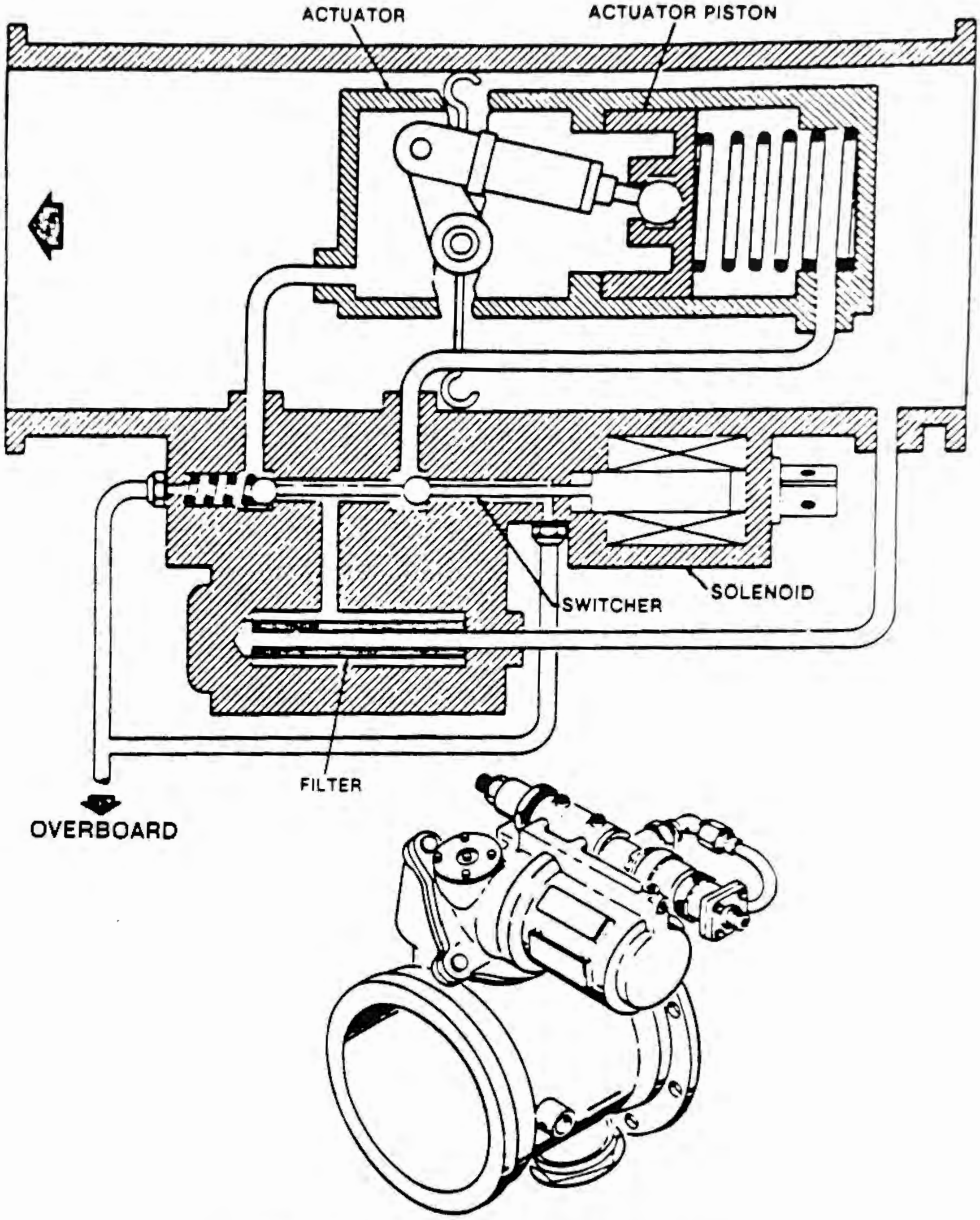
(a) The tail duct valve controls the air supply to the deicing and anti-icing ducts and components of the horizontal stabilizers. The valve is open only when the airfoil deicing system is operating. It is located in the forward end of the tail duct at the juncture of the wing and fuselage sections of the airplane pneumatic manifold (left side).

(b) The valve is an electrically controlled, pneumatically actuated butterfly valve, requiring both electrical and pneumatic power to open. The valve closes any time electrical power is removed from the solenoid, even in the absence of pneumatic power.

(3) Airfoil Deicing Valve (See Figures 30-6 and 30-7)

(a) Airfoil deicing valves are used in the deicing system to cycle air from the pneumatic ducts to the D-ducts that are located in the leading edge of the wings. The D-ducts are divided into sections and each section is supplied with air from the pneumatic duct system through a deicing valve. The valves are attached to the supply duct with V-band clamps and are connected to their respective D-duct section with a flexible connector and a band-type clamp. A total of 12 deicing valves are used in the system: six in each wing.

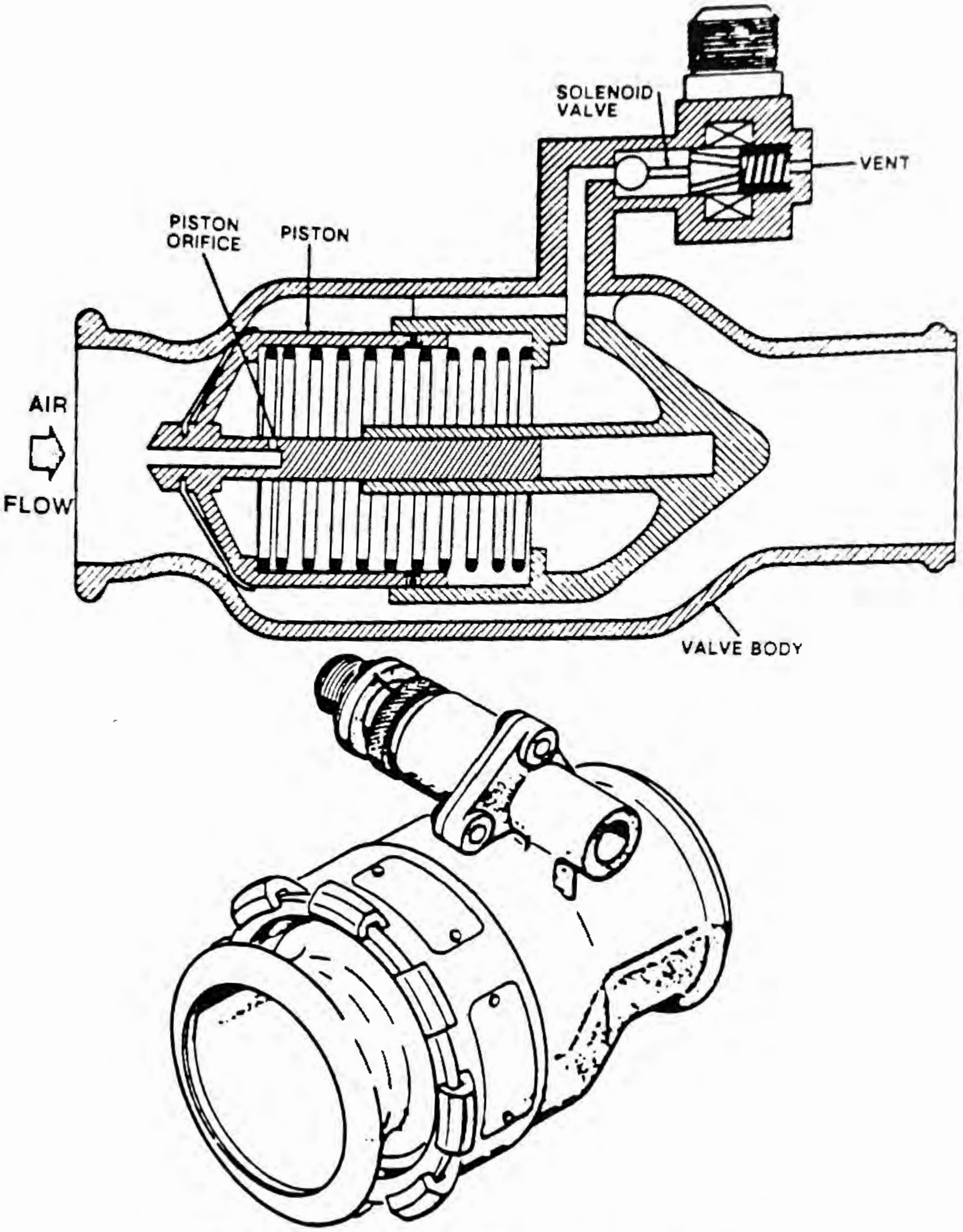
(b) In each wing, one valve is located between the fuselage and the inboard pylon to deice the wing slot area (inner-wing valve), two valves are located between the pylons (center-wing valves), and three valves are located outboard of the outboard pylons (outer-wing valves). All deicing valves are electrically controlled and pneumatically actuated. Air from the low-pressure pneumatic system is always available to the center-wing and inner-wing valves when the pneumatic manifold is pressurized. Air from the pneumatic system is available to the outer-wing valves and to the stabilizer valves when, during operation of the deicing or anti-icing system, the tail duct valve and the outer wing pneumatic duct shutoff valves are open. The valves return to the normally-closed position when electrical power is removed from the solenoid.



TAIL DUCT VALVE SCHEMATIC

FTX80512

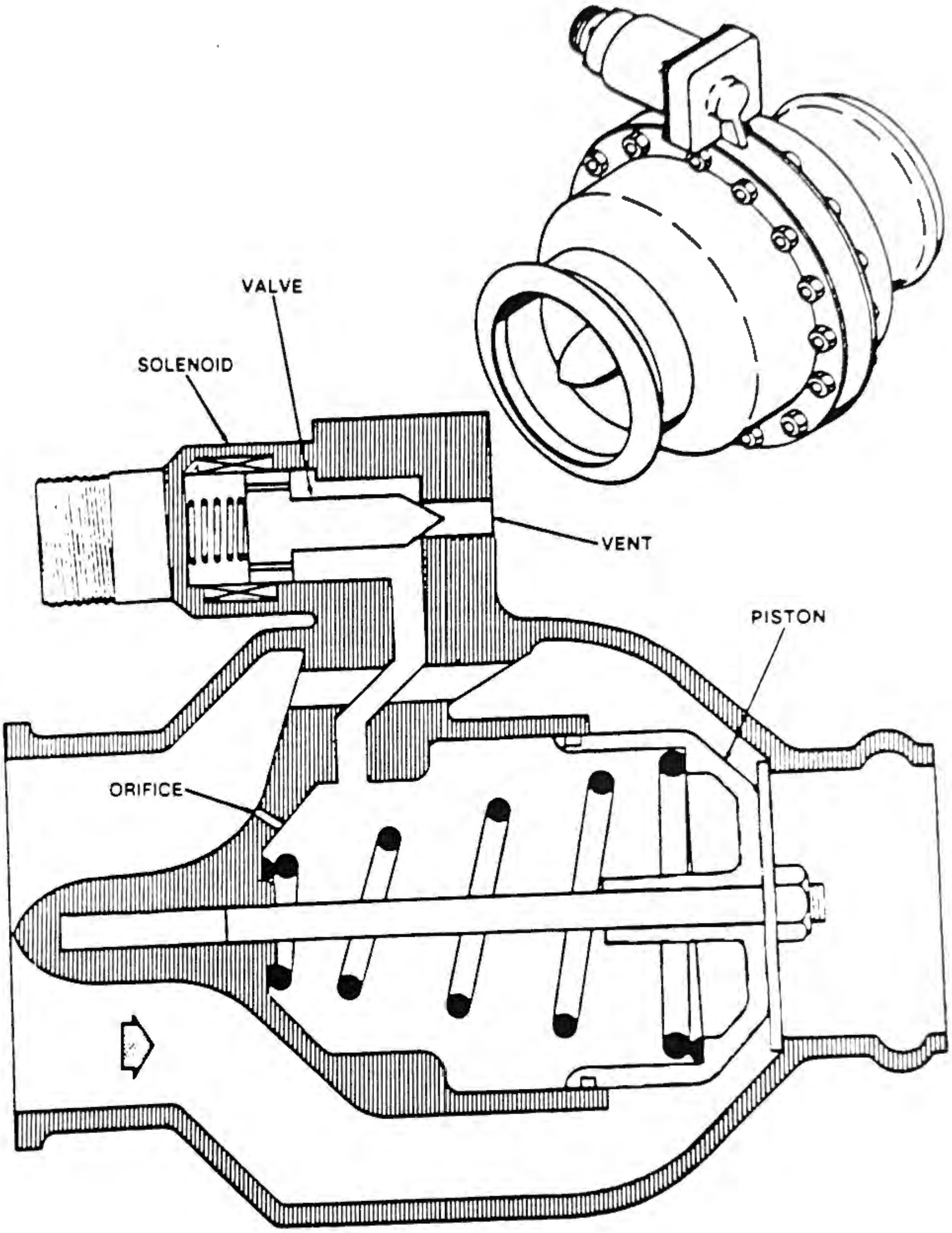
Figure 30-5



OUTER WING DEICING VALVE SCHEMATIC

Figure 30-6

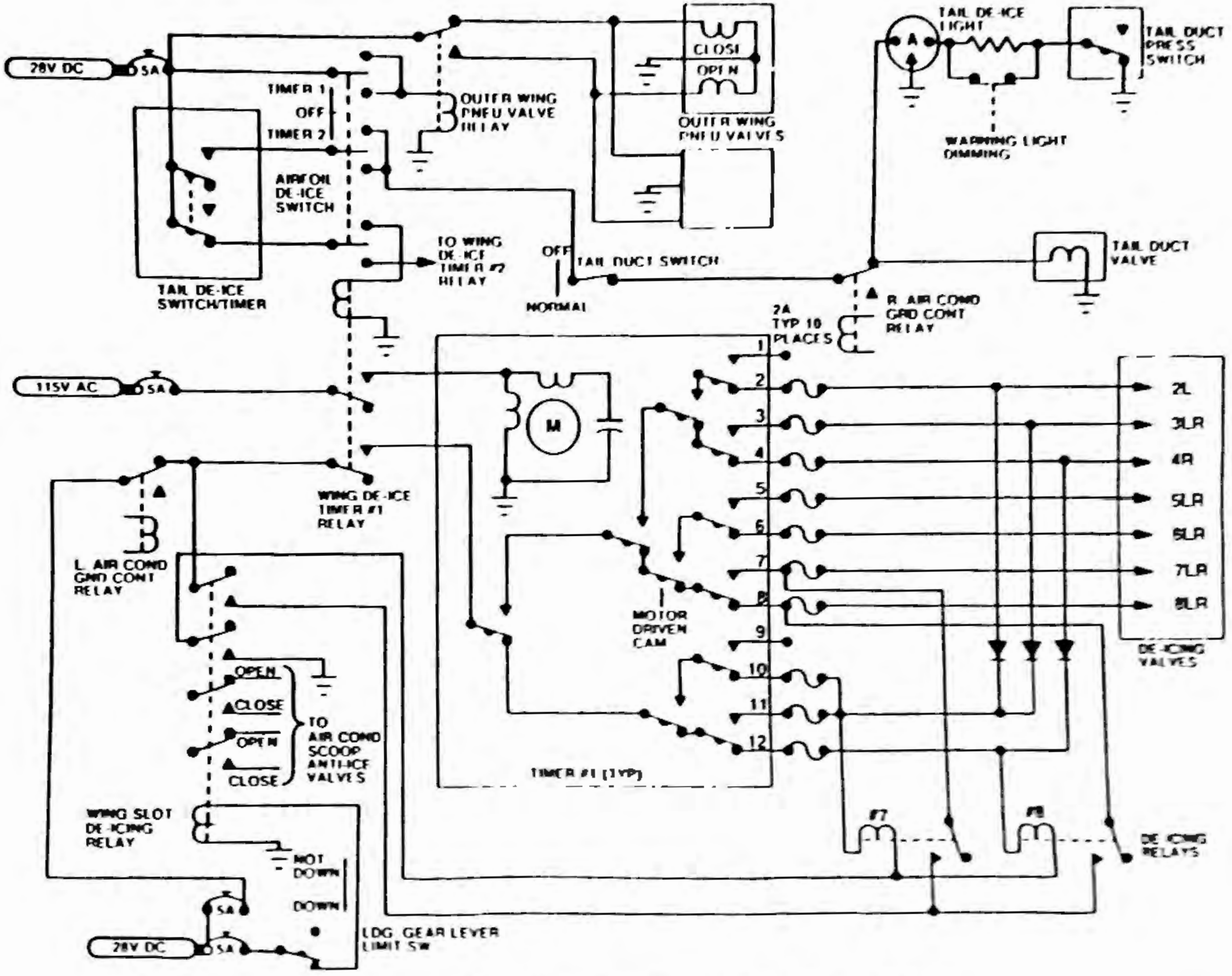
FTX80513



INNER WING DEICING VALVE

FTX80514

Figure 30-7



DE-ICING CONTROL SYSTEM SCHEMATIC

FTX80518

Figure 30-11

(4) Airfoil Deicing Timers (See Figures 30-8 & 30-9)

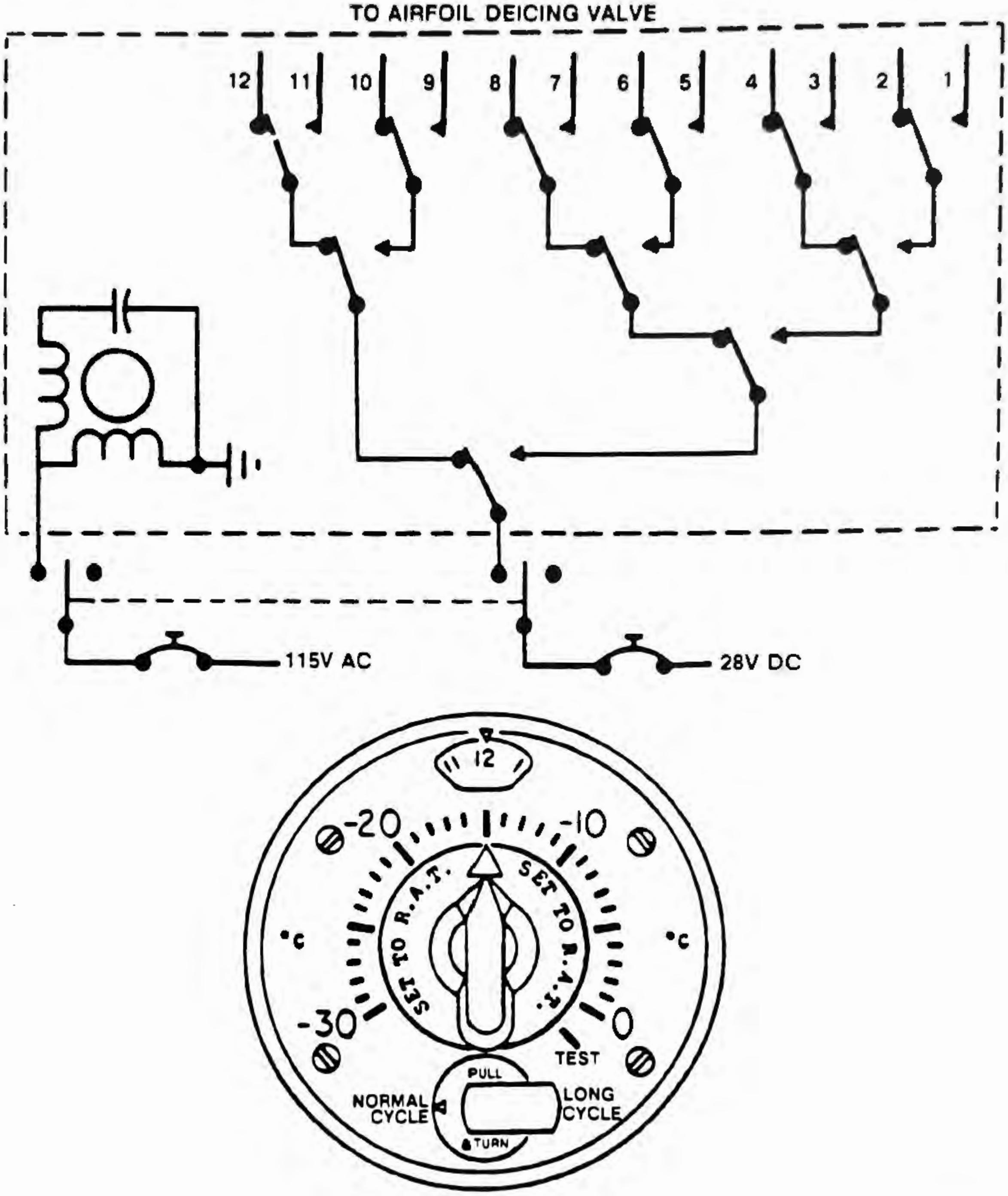
(a) The airfoil deicing timers control the on-off cycling of the airfoil deicing valves. Two timers are mounted on the systems engineer's control panel. One timer acts as the standby while the other one is connected in the circuit through the airfoil deicing switch.

(b) The timers have an airfoil deicing timer cycle selector knob and an airfoil deicing timer temperature selector knob. The dial is graduated from 0° to -30° C for ram-air temperature selections. The switch-actuating camshaft in the timer is driven faster or slower by a variable speed drive that is controlled by the temperature selector knob. When the deicer timer selector knob is placed in the test position, the timer will go through the complete cycle in 23 to 31 seconds. The manually-set cycle selector knob determines cycle time according to the ram-air temperature indication. The cycle time can be doubled by pulling out and turning the the cycle selector knob from the normal cycle to the long cycle position.

(c) A portion of a dial is seen through a window in the face of the timer. The number of the airfoil deicing valve that should be open at any given time appears in the window of the timer.

(5) Tail Duct Venturi Differential-Pressure Switch (See Figure 30-10)

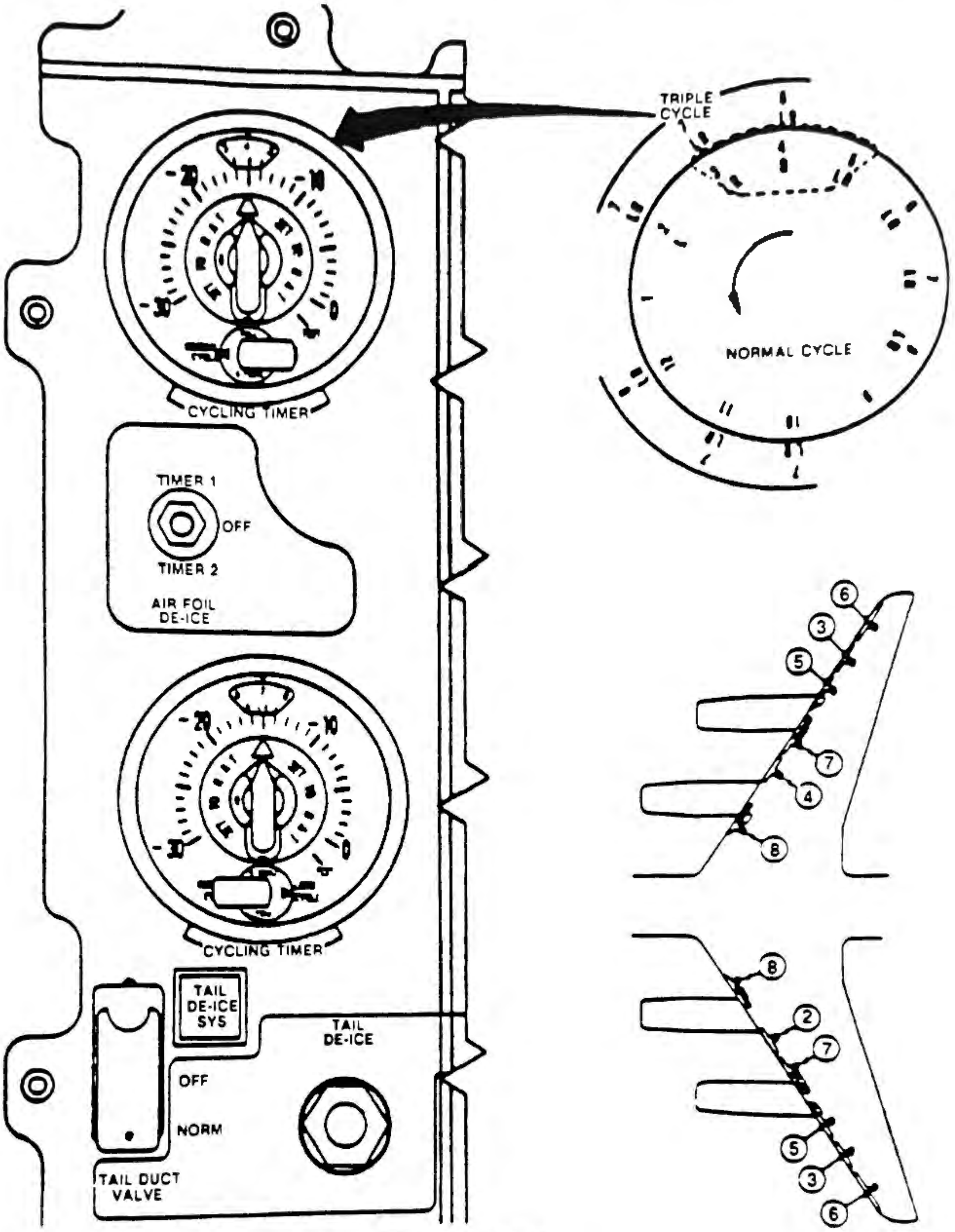
The tail duct venturi differential-pressure switch is installed in the airfoil deicing system to operate an amber indicating light in the flight compartment. The differential- pressure switch, connected to the venturi downstream of the tail duct valve, senses any malfunction in the tail section that causes low airflow, and completes an electrical circuit to operate the indicating light. Differential-pressure across the tail duct venturi actuates a diaphragm to which the load contacts are connected.



AIRFOIL DEICING TIMER

FTX80515

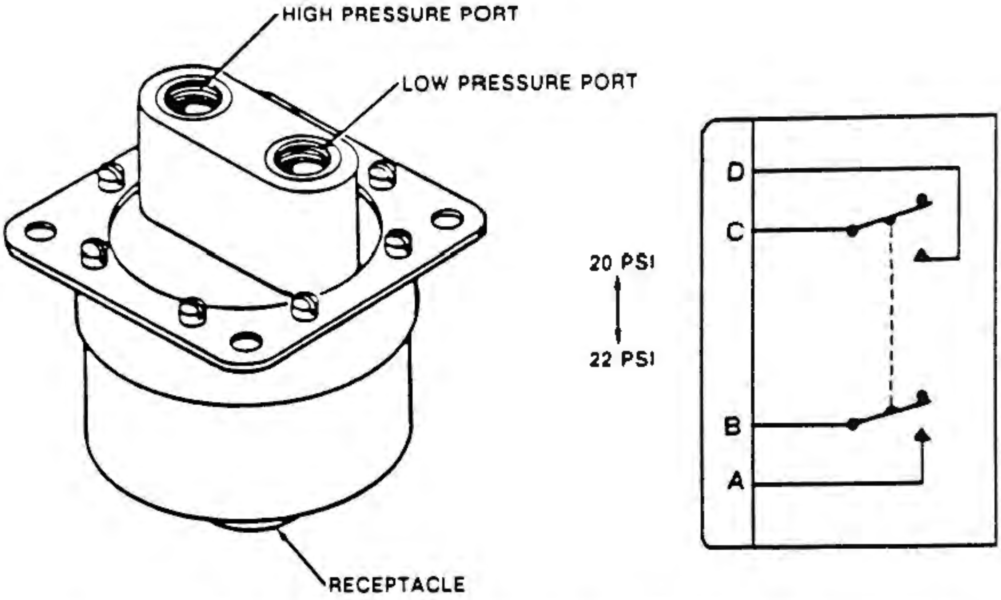
Figure 30-8



DEICING TIMER

FTX80516

Figure 30-9



TAIL DUCT VENTURI DIFFERENTIAL PRESSURE SWITCH

FTX80517

Figure 30-10

C. Operation (See Figure 30-11)

(1) The airfoil deicing system is set in operation by placing the following controls in the noted position:

(a) Tail duct valve switch....... normal

(b) Airfoil deicing timer cycle selector knob....... normal cycle

(c) Airfoil deicing timer temperature selector knob....... at ram-air temperature

(d) Airfoil deicing switch....... timer 1 or timer 2.

NOTE: **The deicing valves are deactivated on the ground through the operation of the left air-conditioning ground control relay. This feature is incorporated in the system to avoid overheating the structure.**

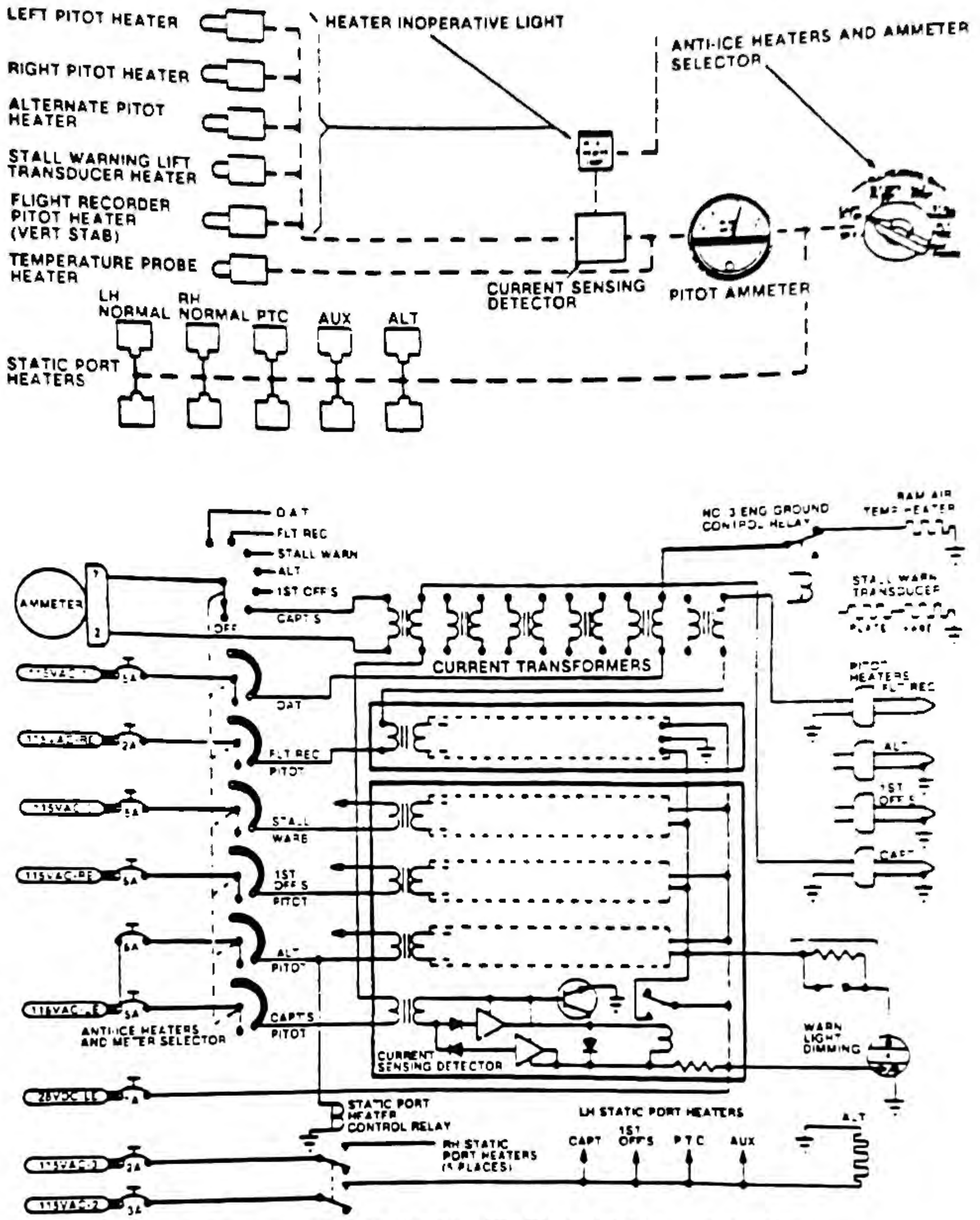
(2) When the airfoil deicing switch is placed in timer 1 or timer 2 position, air from the supply ducts and the manifold is directed to the airfoil leading edges and wing leading edge slots through the deicing valves. These valves are electrically controlled by the selected timer to supply air to one or more sections of the D-duct in the leading edge of each airfoil. Through the action of the timer, air is supplied intermittently and in sequence to corresponding sections of the D-duct. This section electrically controls the opening and closing rate of the deicing valves. One deicing cycle is completed when all wing leading edge areas have received deicing air. This cycle is repeated until the airfoil deicing switch is placed in the off position.

(3) When the airfoil deicing switch is placed in timer 1 or timer 2 position, and the tail deice pushbutton is energized the tail deicing valve will open and begin a 150-second cycle at which time high pressure hot air will flow to the tail deicing ports, deicing the tail. If during any cycle the tail deice push button is reenergized a second 150-second cycle will begin.

(4) To prevent the formation of runback ice, and to shed secondary ice, an airfoil deicing timer cycle selector knob, is provided at the bottom of the timer dial for selecting a normal cycle or a long cycle. When the knob is positioned from normal cycle to long cycle prior to turning off

the deicing system, the length of time that the deicing valves remain open is doubled. A small portion of a rotating dial is visible in a window at the top of the timer. The identifying number of the airfoil deicing valves that should be open at any given time appears in the window of the timer, with the exception of positions 11 and 12. These positions have no corresponding valves since the vertical stabilizer is not deiced. The letter adjacent to the number indicates the general location of the valves; for example, L for left wing, R for right wing, and T for tail.

(5) During approach and landing operations, it is necessary that the wing slot areas be deiced more frequently than the unslotted areas. When the landing gear control lever is placed in the down position, the slotted area deicing valves open for three extra intervals during the same time that all the valves are operating in their regular sequence. With the landing gear control lever in this position, the fuselage nose anti-icing valves are locked closed to conserve engine bleed air.



PITOT AND STATIC PORT HEATING STALL WARNING AND TEMP PROBE HEATING SYSTEM

FTX80521

Figure 30-14

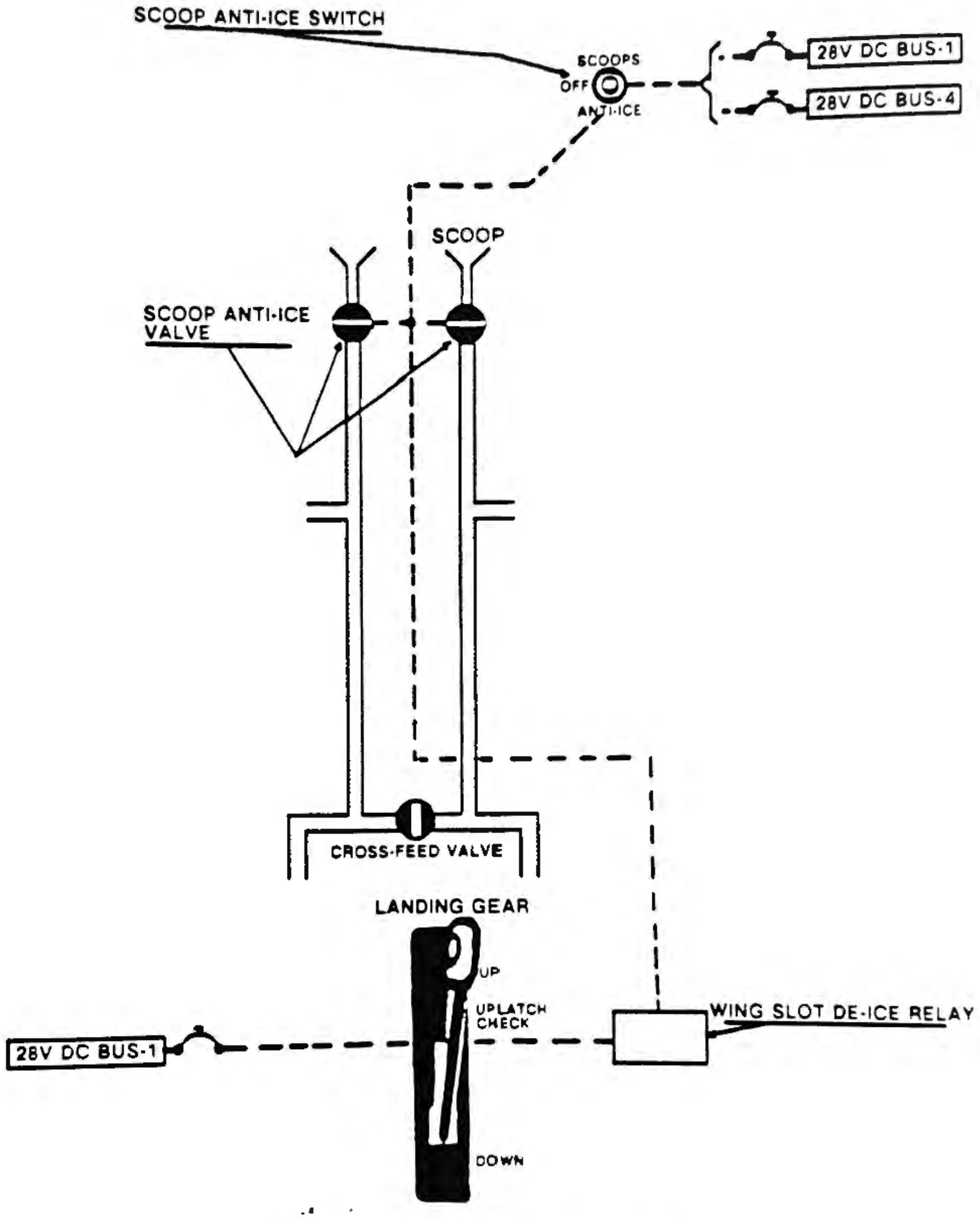
3. Air Intakes - Description and Operation

A. Description (See Figures 30-12 & 30-13)

The air intakes consist of the fuselage nose air-conditioning scoop anti-icing valves. The fuselage nose anti-icing valves control the flow of high-temperature engine bleed air from the low-pressure pneumatic manifold to the air-conditioning air intake scoops. The valves are installed in the anti-icing ducts located in the lower fuselage nose area.

B. Operation

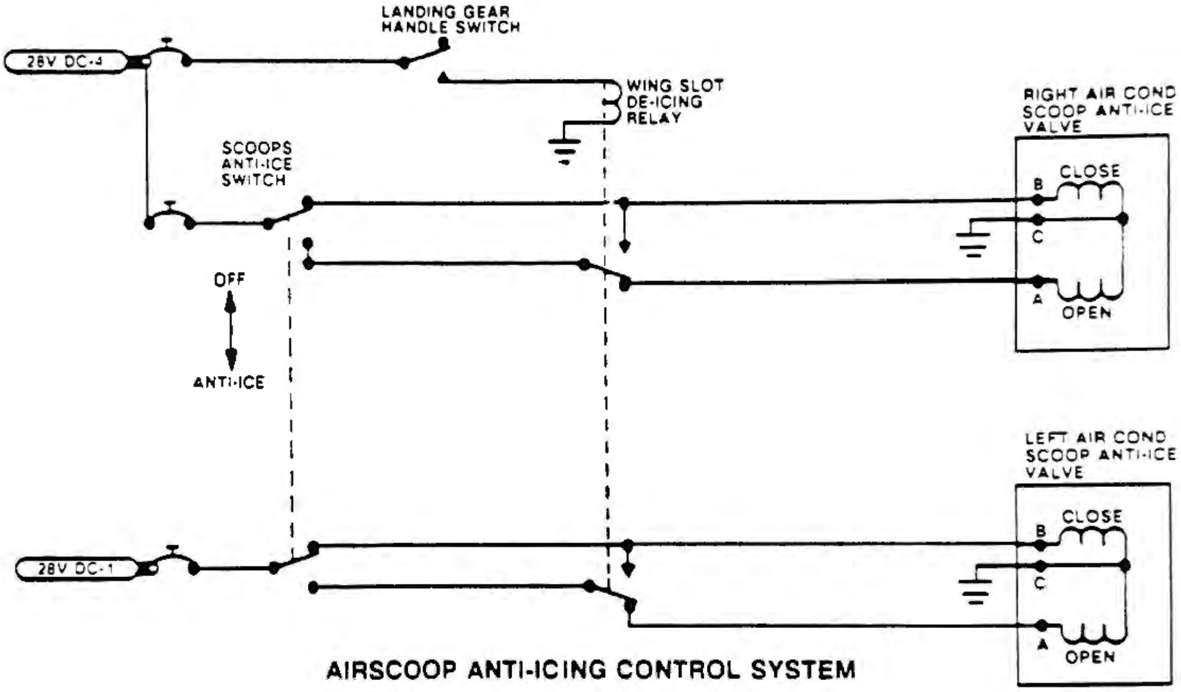
The pneumatically actuated poppet-type valves are electrically controlled by an anti-icing switch located on the overhead switch panel. When the valve solenoids are electrically energized, air pressure from the low-pressure pneumatic manifold opens the valves. This allows anti-icing air to flow to the air-conditioning air intake scoops.



SCOOP ANTI-ICE SCHEMATIC

FTX80519

Figure 30-12



AIRSCOOP ANTI-ICING CONTROL SYSTEM

FTX80520

Figure 30-13

4. Pitot and Static - Description and Operation

A. General (See Figure 30-14)

Ice protection is provided by electrical heating elements for the captain's, first officer's, flight recorder, and alternate pitot tubes, the stall warning lift transducer, the static ports, and the outside air temperature sensors. The anti-icing heating system is comprised of the pitot tube and static port heating elements, the heater for the stall warning lift transducer and outside air temperature sensors, the anti-icing heater and ammeter selector switch, the current sensing detector, the heater transformer, and the heater failure indicating light.

B. Description

(1) The heating elements consist of fine resistance wire sealed in the assembly, with provisions for external connection to AC power. The anti-icing heater and ammeter selector switch, located on the overhead switch panel, is a rotary-type switch. The switch connects power to the heater elements through the current sensing detector and heater transformer and also arms the failure indicating light circuit. When the switch is in any of the on positions, all the heaters are energized. The ammeter, located adjacent to the switch, indicates the electrical load of the heater corresponding to the switch position through the heater transformer. The current sensing detector, located on the EPC aft center equipment panel, consists of a transformer that supplies power to operate a relay coil, and contacts that interlock the failure indicating light circuit. The heater failure light is located on the overhead switch panel and is a push-to-test, dimmable, amber light. When the pitot heater switch is on, the light goes on if there is a malfunction in any of the pitot heaters.

CAUTION: TO PROLONG SERVICE LIFE OF PITOT TUBE AND LIFT TRANSDUCER HEATING ELEMENTS, MAKE CERTAIN THAT ANTI-ICING HEATERS SWITCH IS TURNED OFF WHEN AIRPLANE IS ON GROUND.

(2) The heating element for the static ports consist of an aluminum sleeve onto which is wound a heating element, with provisions for external connection to AC power. The heater switch connects power to the static port heater control relay and 115 VAC is supplied to the heater element through the relay contacts.

5. Windows and Windshield - Description and Operation

A. General

(1) The windshield panels (left, center, and right), the two eyebrow windows and the two clearview windows are electrically heated by elements (conductive coatings) in the glass. The heated glass provides a shock-resistance surface for flying objects. The windshields are heated on both inner and outer surfaces which also provides anti-icing and anti-fogging of the glass. The four windows are heated on the inner surfaces only.

(2) Temperatures of the outer surfaces of the windshield panels are sensed by sensing elements which work in conjunction with the temperature controllers to regulate current flow to the heating elements.

(3) The inner (anti-fogging elements) are controlled by thermal switches on the glass which make or break the electrical circuits to the heating elements, thereby controlling the temperature. The anti-fogging system is used during certain weather conditions on the ground to clear the windshields and windows and shorten dispatch time, and in the air to prevent fogging of the glass during rapid ascent or descent.

(4) A pneumatic and a liquid rain repellent system are provided for the left and right windshields. The pneumatic rain removal system operates from the pneumatic system and is controlled by levers in the flight compartment and may be operated either independently, or in conjunction with, the rain repellent system.

(5) The rain repellent system is controlled by a switch in the flight compartment. When the switch is depressed, rain repellent fluid is sprayed on the surfaces of the left and right windshield from spray nozzles near the lower edge of the windshields. The fluid when spread by pneumatic source or the slipstream, causes water to form into beads and roll of the glass.

(5) A windshield pneumatic rain removal system is provided for the left and right windshields. Bleed air from the pneumatic system is ducted through the pneumatic manifold to the rain removal shutoff valves and is controlled by levers in the flight compartment. When opened, the valves allow an air blast to pass through plenum chambers, which direct the air onto the windshields, causing water to form into beads and roll off the glass.

6. Windows and Windshield Anti-Icing/Anti-Fogging - Description and Operation

A. General (See Figure 30-17)

(1) Each windshield panel (left, center, and right) is electrically heated by two elements installed in the glass. One element (conductive coating) is fused to the aft face of the outer glass ply and the other is fused to the forward face of the inner glass ply of each panel. The heating effect of both elements provides elasticity enabling the panel to withstand impact force from flying objects. Electrical heating provides anti-icing of the external surface (see Figure 30-16) and anti-fogging on the internal surface of the glass (see Figure 30-15). An element (conductive coating) is also fused to the forward face of the inner glass ply of the two eyebrow windows and two clearview windows to provide anti-fogging of the internal surfaces.

(2) The window and windshield heating system consists of the following components:

(a) Two temperature sensing elements for windshield anti-icing, sealed in the inner ply of each windshield panel (one in use; the other for standby).

(b) Heating elements (conductive coatings), one in each window and two in each windshield panel.

(c) Thermal switches, one in inside surface of each clearview and eyebrow window, and windshield panel.

(d) Temperature controllers, one for each windshield, located in the electrical power center forward equipment panel.

(e) Transformers, one for each windshield anti-ice electrical system,located in the electrical power center forward panel.

(f) Windshield heater switch located on the forward overhead switch panel.

(g) Anti-fog relay, one for all heated glass panels, located on the electrical power center forward equipment panel.

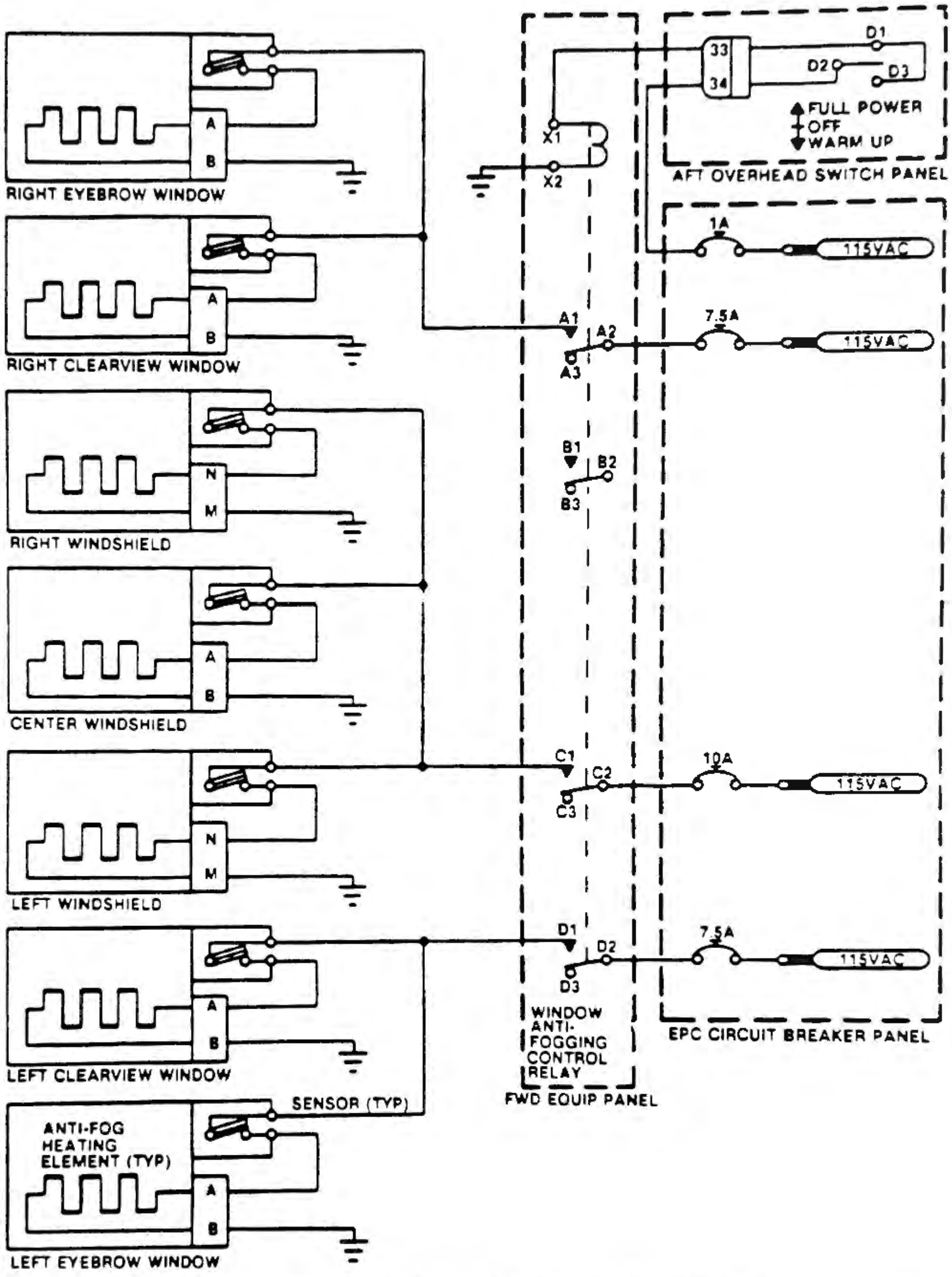
(h) Windshield temperature control relays, two for each windshield, located in the EPC forward equipment panel.

The windshield temperature controller is a solid state electronic device that controls the temperature of the glass panels by switching electrical power on and off as required. Input electrical power to each controller is 115 VAC. The output of each controller is routed through a step up transformer where the voltage is stepped up to supply approximately 254 VAC to the windshield heating element with the control switch in warm-up or approximately 350 VAC with the control switch in full power position.

B. Operation

(1) Temperature control of each windshield panel for shock-proofing and anti-icing is accomplished by sensing elements installed in the glass working in conjunction with a temperature controller. The elements, affected by the temperature of the glass, signal the controller to switch on or off the electrical power to the heating elements in the glass.

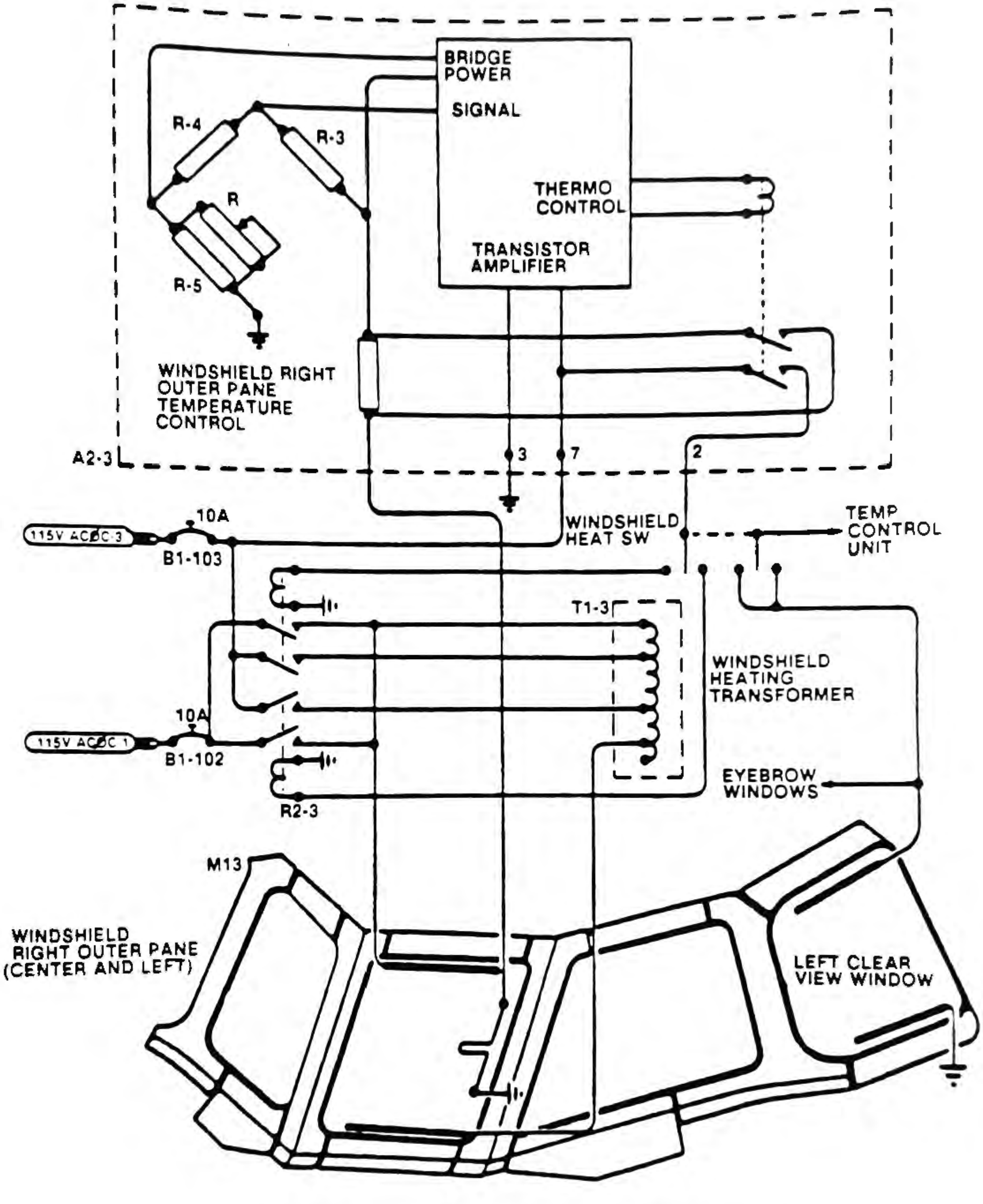
(2) The anti-fog heating system is not normally used, as heating of the inner surfaces of the glass is required only under certain weather conditions. The windshield ice protection switch controls both the windshield heat and anti-fogging electrical circuits, however the cockpit window anti-fog control circuit breakers are normally left open to permit operation of windshield heat without turning on the anti-fogging system. When the windshield ice protection switch is turned on, and the anti-fog circuit breakers are closed, the windshield defog control relay is energized to close the circuits to the anti-fogging heating elements. The anti-ice circuits are closed directly by the switch. As temperatures of the inner glass panel of each windshield and window change, the thermal switches mounted against the glass make or break the circuitry to the anti-fogging heater elements to control temperature.



WINDOW AND WINDSHIELD ANTIFOGGING SYSTEM

FTX80523

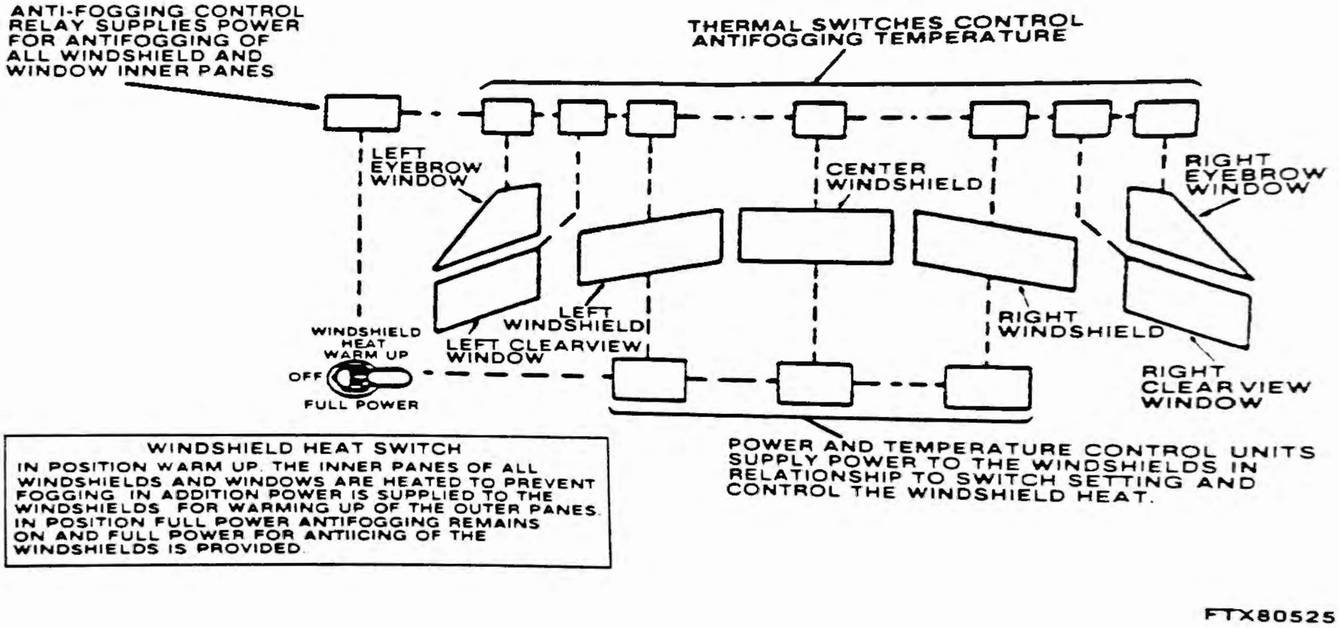
Figure 30-15



WINDSHIELD AND WINDOW HEATING

Figure 30-16

FTX80524



ANTI-FOGGING CONTROL RELAY SUPPLIES POWER FOR ANTIFOGGING OF ALL WINDSHIELD AND WINDOW INNER PANES

THERMAL SWITCHES CONTROL ANTIFOGGING TEMPERATURE

POWER AND TEMPERATURE CONTROL UNITS SUPPLY POWER TO THE WINDSHIELDS IN RELATIONSHIP TO SWITCH SETTING AND CONTROL THE WINDSHIELD HEAT.

WINDSHIELD HEAT SWITCH

IN POSITION WARM UP. THE INNER PANES OF ALL WINDSHIELDS AND WINDOWS ARE HEATED TO PREVENT FOGGING IN ADDITION POWER IS SUPPLIED TO THE WINDSHIELDS FOR WARMING UP OF THE OUTER PANES. IN POSITION FULL POWER ANTIFOGGING REMAINS ON AND FULL POWER FOR ANTIICING OF THE WINDSHIELDS IS PROVIDED.

Figure 30-17

7. Windshield Pneumatic Rain Removal System - Description and Operation

A. General

(1) Description

The windshield pneumatic rain removal system uses hot air from the pneumatic system to divert rain from the left and right windshields during flight. Air is supplied to the left windshield from the left pneumatic rain removal duct and to the right windshield from the right pneumatic rain removal duct. Both rain removal ducts receive air from the airplane pneumatic manifold. A cable-operated shutoff valve is installed in each rain removal duct. The air is directed upward through an external slotted nozzle at the base of the windshield with enough velocity to keep the windshield clear. The system is manually operated by a lever located on each pilot's console. The lever operates a cable system that opens the shutoff valve and allows air from the low-pressure pneumatic system to flow through the valve to the rain removal nozzles and over the windshield. The pattern of airflow depends on the forward movement of the airplane.

CAUTION: RAIN REMOVAL CONTROL LEVERS MUST BE IN OFF POSITION WHEN SYSTEM IS NOT IN USE. IF LEVERS ARE LEFT IN ON POSITION, RAIN OR CONDENSATION MIGHT ENTER CABIN COMPRESSOR AND CAUSE DAMAGE TO COMPRESSORS, WHEN STARTED.

B. System Components (See Figure 30-18)

(1) Shutoff Valves (See Figure 30-19)

(a) The windshield pneumatic rain removal shutoff valves are installed in the fuselage nose section between the rain removal ducts and the plenum chambers. There are two shutoff valves, one for the left windshield and one for the right windshield.

(b) Each valve is actuated through a single cable by a lever mounted on the corresponding pilot's console. Operation of each valve is independent of the other valve. When the valve is opened, hot air is directed to the rain removal nozzles.

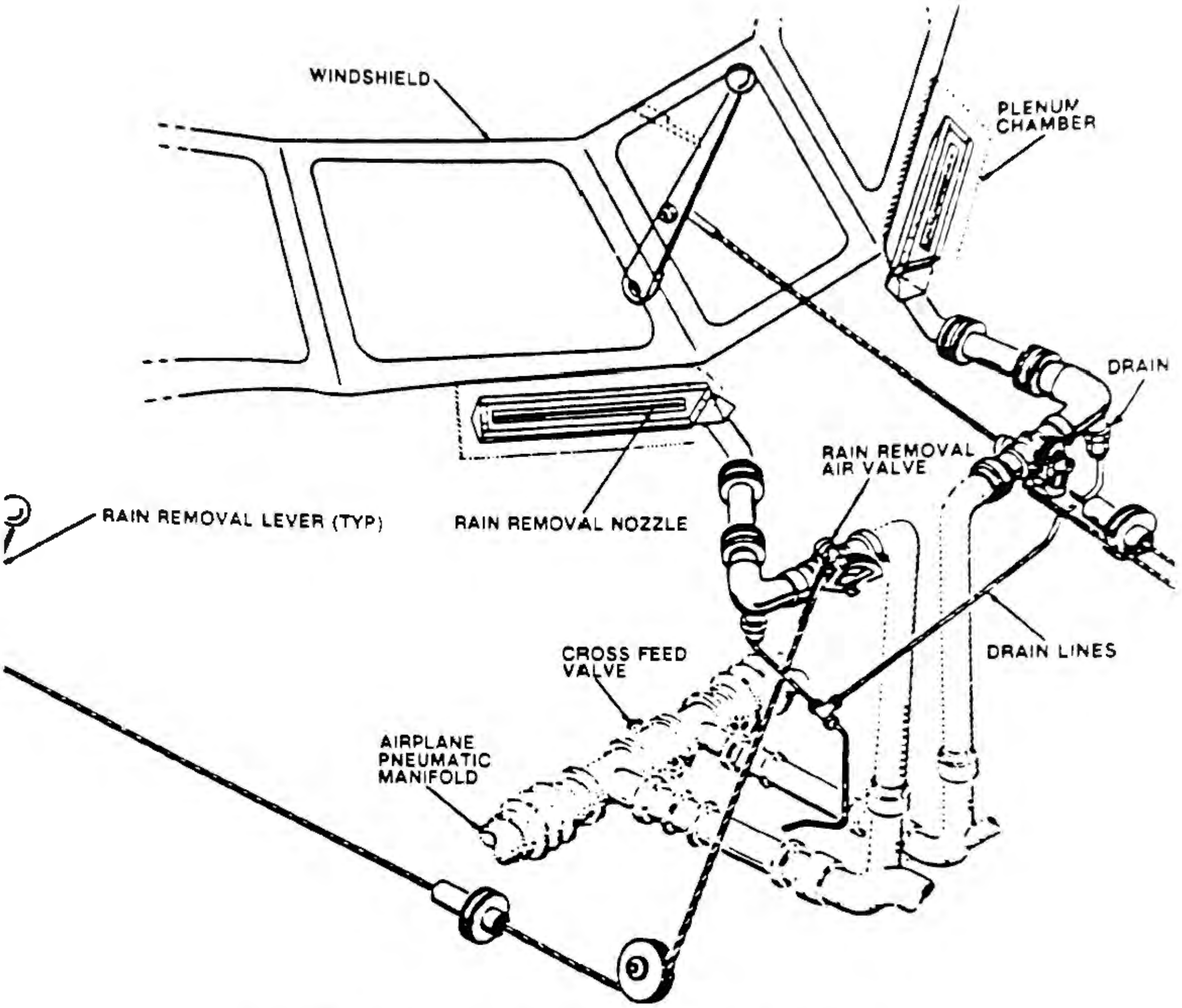
(c) Movement of the lever on either console to the open position operates the respective shutoff valve to the open position. The positive position stop on the cam, splined to the butterfly shaft, positions the valve to the open position. The action of the shaft also winds the spiral spring tighter, allowing the valve to go to the closed position when the lever is moved to the closed position. The single cable positions the valve to the open position and the spring closes the valve. The valve will go to the closed position and will remain closed, if the cable should brake.

(2) Pneumatic Nozzles

The pneumatic rain removal nozzles are located forward of the left and right windshield outer panels. The nozzles are attached to the fuselage nose section plating that forms the access door to the plenum chambers. Air from the low-pressure pneumatic system flows through the rain removal shutoff valves and into the plenum chamber. The nozzles are fixed slots forming an air outlet from the plenum chambers. The nozzles direct the airflow over the windshield at an angle of 6 degrees from the surface of the glass. The small angle prevents overheating of the windshield panels when there is no forward movement of the airplane; however, extended or unnecessary operation of the pneumatic rain removal system on the ground should be avoided.

(3) Drain Valves

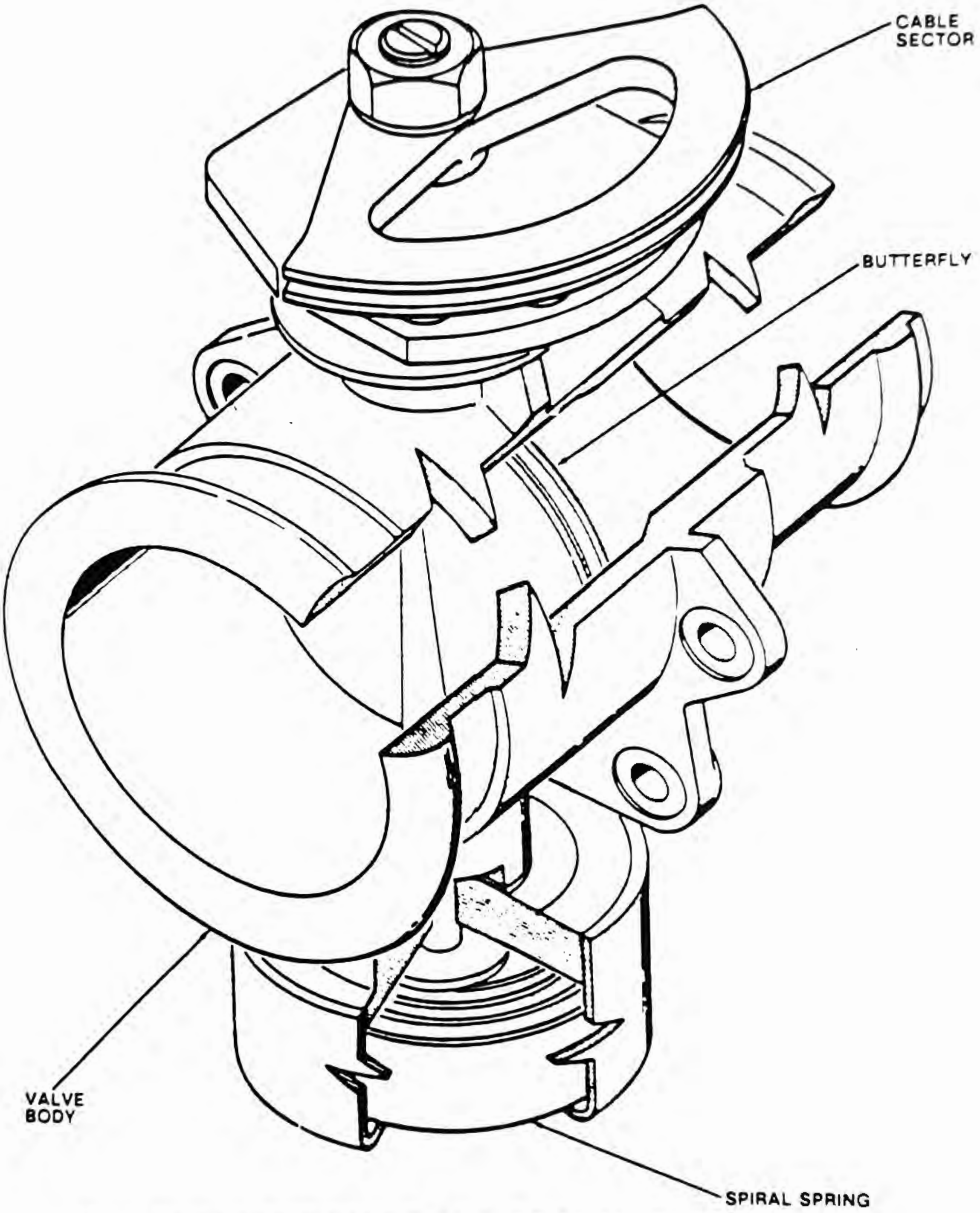
A drain valve is located on the downstream side of each windshield rain removal shutoff valve to provide for the removal of water that might enter the system. These valves are spring loaded to the open position; but, when the pressure in the pneumatic duct builds up to 4 (±2 1/2) psig, the valves close. The air then flows freely to the windshield. When the pressure in the duct is removed (valve closed), the load action of the spring opens the valve.



WINDSHIELD PNEUMATIC RAIN REMOVAL

FTX80526

Figure 30-18



WINDSHIELD PNEUMATIC RAIN REMOVAL SHUTOFF VALVE

FTX80527

Figure 30-19

8. Windshield Liquid Rain Repellent System - Description and Operation

A. General

The liquid rain repellent system uses a liquid rain repellent, stored in a pressurized container, to remove rain from the windshields. The system, on demand, dispenses repellent fluid on the outer surfaces of the left and right windshields, either individually or simultaneously, to aid in removing rain water from these surfaces.

B. Description (See Figure 30-20)

(1) The system consists of one replaceable pressurized fluid container, a transparent fluid level indicator, a pressure gage, two solenoid-actuated valves, two spray nozzles, two momentary pushbutton switches, a control switch, a time delay relay, and the necessary plumbing and wiring to interconnect and operate the system. All components, with the exception of the fluid-dispensing nozzles, are located in the flight compartment. Electrical power is required to actuate the solenoid valves.

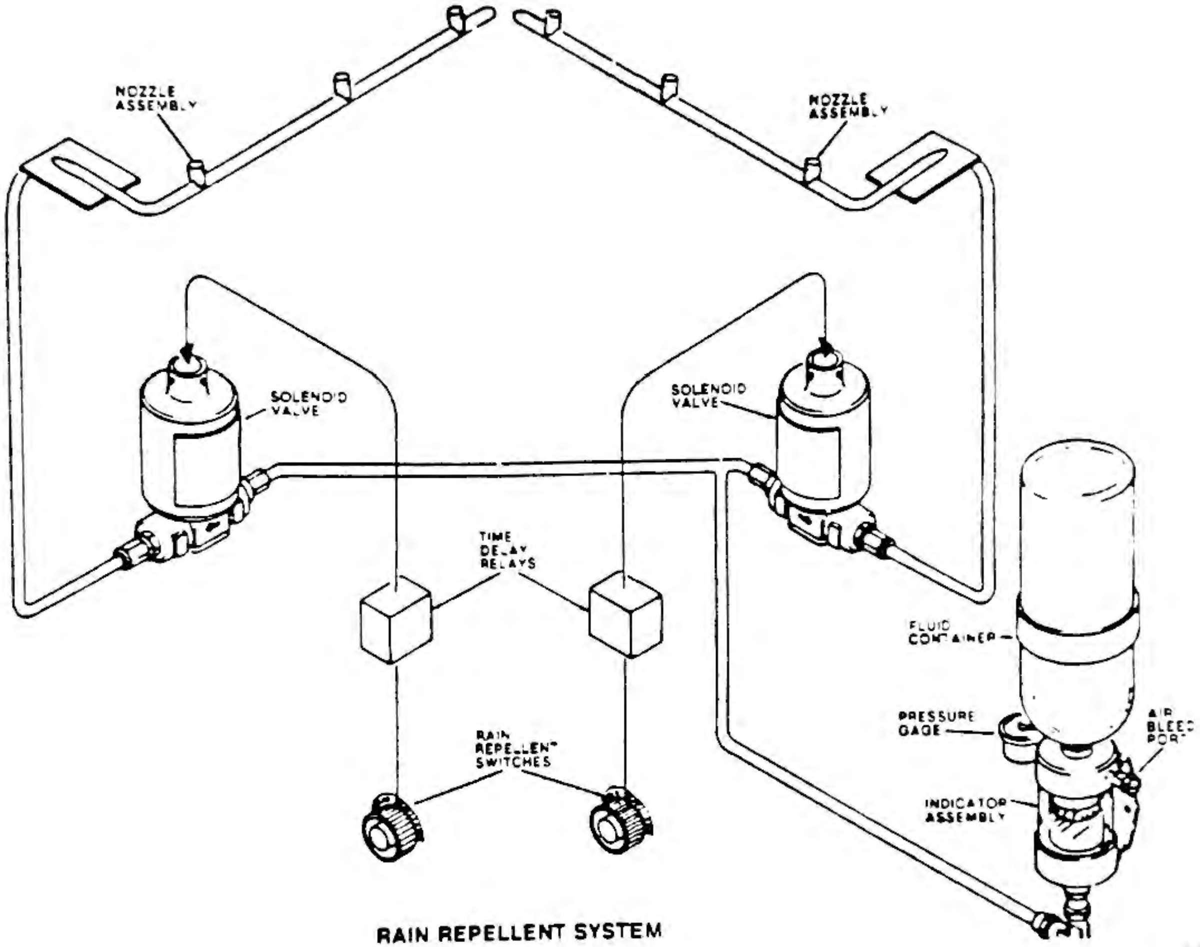
(2) The fluid container, located on the co-pilot's console, is pressurized to approximately 90 psig when fully charged and holds approximately 500 cc. The transparent fluid level indicator and pressure gauge is located below the fluid container and indicates the fluid level and the system pressure. The fluid level indicator check valve is held open when a container is installed in order to prevent line pressure build up. Each solenoid-actuated valve, located just forward of the windshield, is actuated in response to a pushbutton switch. The time delay relay, located in the forward electrical power center, automatically shuts off electrical power to the solenoid approximately 0.24 second after the pushbutton switch is depressed, thus closing the valve. Approximately 6 cc of fluid is dispensed on the windshield while the valve is open. The repellent causes water to form beads and roll off the glass. The slipstream across the windshield will continually remove the water beads leaving a large part of the windshield clear.

(3) The repellent is effective for varying lengths of time, depending on rain intensity. A small amount of washing will make the windshield again receptive to the repellent. The repellent fluid is not a window-washing solution and should never be applied to a dry windshield. When used on a dry windshield, repellent will dry, and visibility will be reduced.

C. Operation

The liquid rain repellent system should be used only during moderate-to-heavy rain, and in conjunction with the pneumatic rain removal system, which helps to spread the fluid across the windshield. To operate the system, depress one or both momentary pushbutton switches. Due to aspiration of the system lines by the slipstream, the momentary pushbutton switches may have to be depressed several times (during the initial surge) in order to pressurize the lines and dispense the fluid on the windshield. When the pushbutton is depressed, the solenoid valve opens for 0.24 second, and approximately 6 cc of fluid is sprayed on the windshield. Because fluid is supplied to both windshields from the same container, it is desirable to depress one pushbutton switch before the other to spray the maximum amount of fluid on the windshield. However, both switches may be activated simultaneously, if required. The fluid quantity can be monitored on the transparent fluid level indicator and the container pressure can be monitored on the pressure gage.

WARNING: THE LIQUID RAIN REPELLENT SYSTEM MUST NOT BE LEFT WITHOUT A CONTAINER INSTALLED, UNLESS THE SYSTEM BLEED PORT VALVE IS OPENED. UNDESIRABLY HIGH PRESSURE CAN DEVELOP IN THE CLOSED SYSTEM UNDER CERTAIN AMBIENT TEMPERATURE CONDITIONS, IF A CONTAINER IS NOT INSTALLED.



RAIN REPELLENT SYSTEM

Figure 30-20

(7) The engine anti-icing air regulators (See Figures 30-24 & 30-28) control the flow of anti-icing air supplied to the engine inlet. The air regulators are located on each side of the engine adjacent to the air shutoff valves and are installed in the anti-icing air ducts.

B. Operation (See Figures 30-25, 30-26 & 30-27)

To initiate operation, the anti-icing control switch is placed in the anti-ice position and the following sequence of events occurs:

(1) A circuit is completed from a DC bus, through a circuit breaker and the control switch, to the anti-icing air shutoff valves.

(2) At the same time, the engine anti-icing switch arms one of two indicating light limit and position indicating switches in each engine valve actuator. As the engine valves move, these switches open the indicating light circuit. The light comes on momentarily when the engine anti-icing control switch is moved to a new position. As the valves move in response to control switch position, the limit and position indicating switch opens the circuit and the light goes off. If the valve fails to move, the light remains on, indicating an engine valve malfunction.

(3) As the engine anti-icing valves open, hot compressed air flows through the anti-icing valves and air regulator, through the system tubes, into the continuous manifold ring of the engine inlet case. The ring encircles the engine inlet guide vanes, the outer end of which connect to the ring. The inner end of each vane connects to the inlet bullet. Airflow continues through the ring into the hollow cavities in the guide vanes and inlet bullet and exhausts into the engine inlet stream.

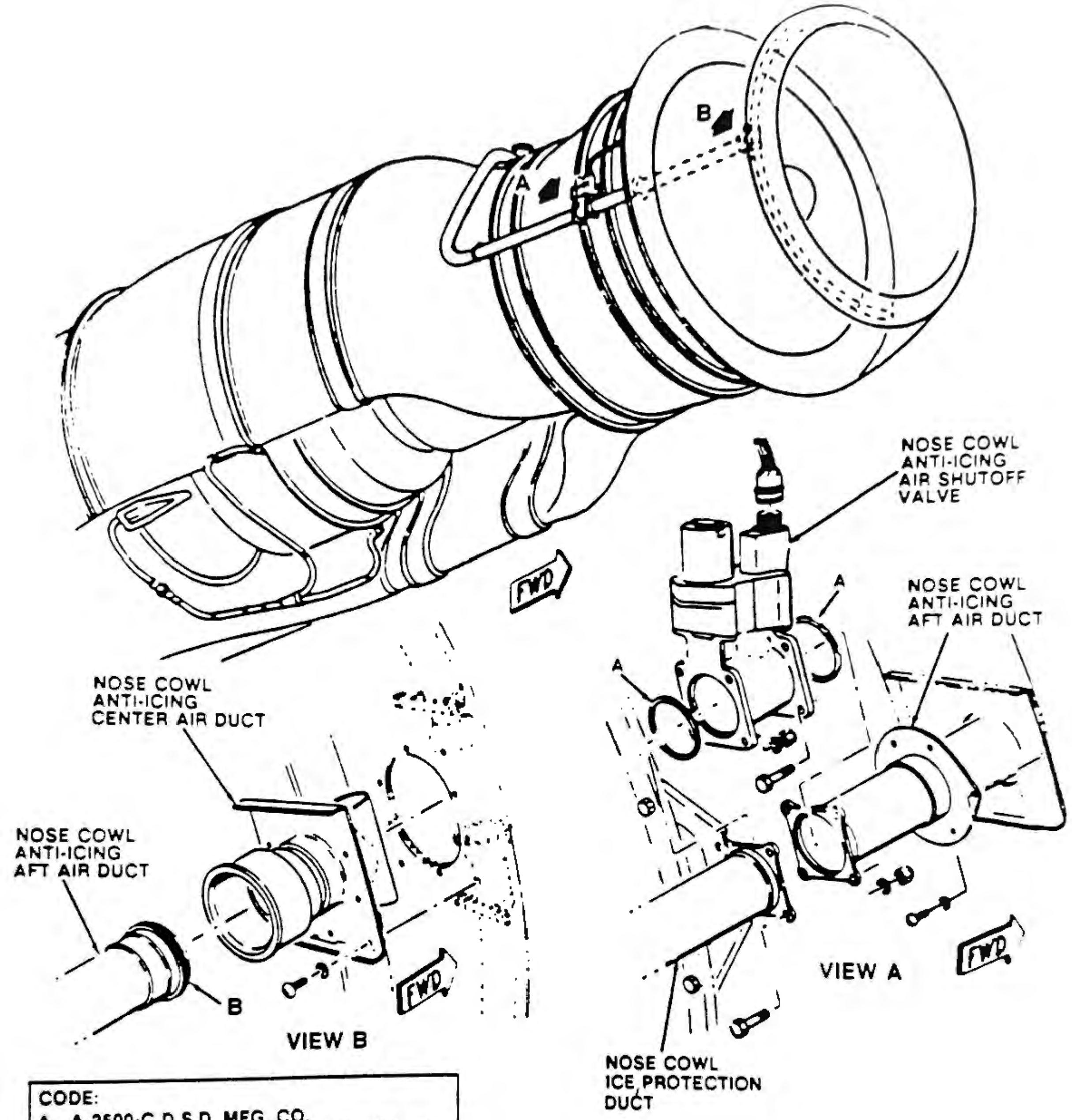
(4) At the same time that the engine anti-icing valves open, the nose cowl anti-icing valve opens. This permits air from the pneumatic manifold to anti-ice the nose cowl.

(5) As air temperature increases, the air regulator valve moves to the closed position, limiting airflow to the engine inlet. As air temperature decreases, the valve moves to the open position and increases the flow of air. The air regulator valve modulates between open and close, supplying anti-icing air.

9. General - Description and Operation

A. Description (See Figure 30-21)

The engine anti-icing system utilizes compressor bleed air to anti-ice the inlet guide vanes and inlet bullet, and low-pressure pneumatic air to anti-ice the nose cowl leading edge.


B
A
FWD
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE
A
NOSE COWL ANTI-ICING AFT AIR DUCT
A
NOSE COWL ANTI-ICING CENTER AIR DUCT
NOSE COWL ANTI-ICING AFT AIR DUCT
B
FWD
VIEW B
VIEW A
FWD
NOSE COWL ICE PROTECTION DUCT

CODE:
A. A-2500-C D.S.D. MFG. CO.
B. B650510 PRECISION PISTON RINGS, INC.

GENERAL PACKING LOCATION

FTX80530

Figure 30-21

10. Engine Anti-Icing - Description and Operation

A. General

(1) Engine anti-icing prevents ice formation on the compressor inlet guide vanes, inlet bullet, and nose cowl leading edge.

(2) Engine and inlet bullet anti-icing air is provided by air obtained from the compressor bleed air manifold. Nose cowl anti-icing is provided by air obtained from the low-pressure pneumatic system.

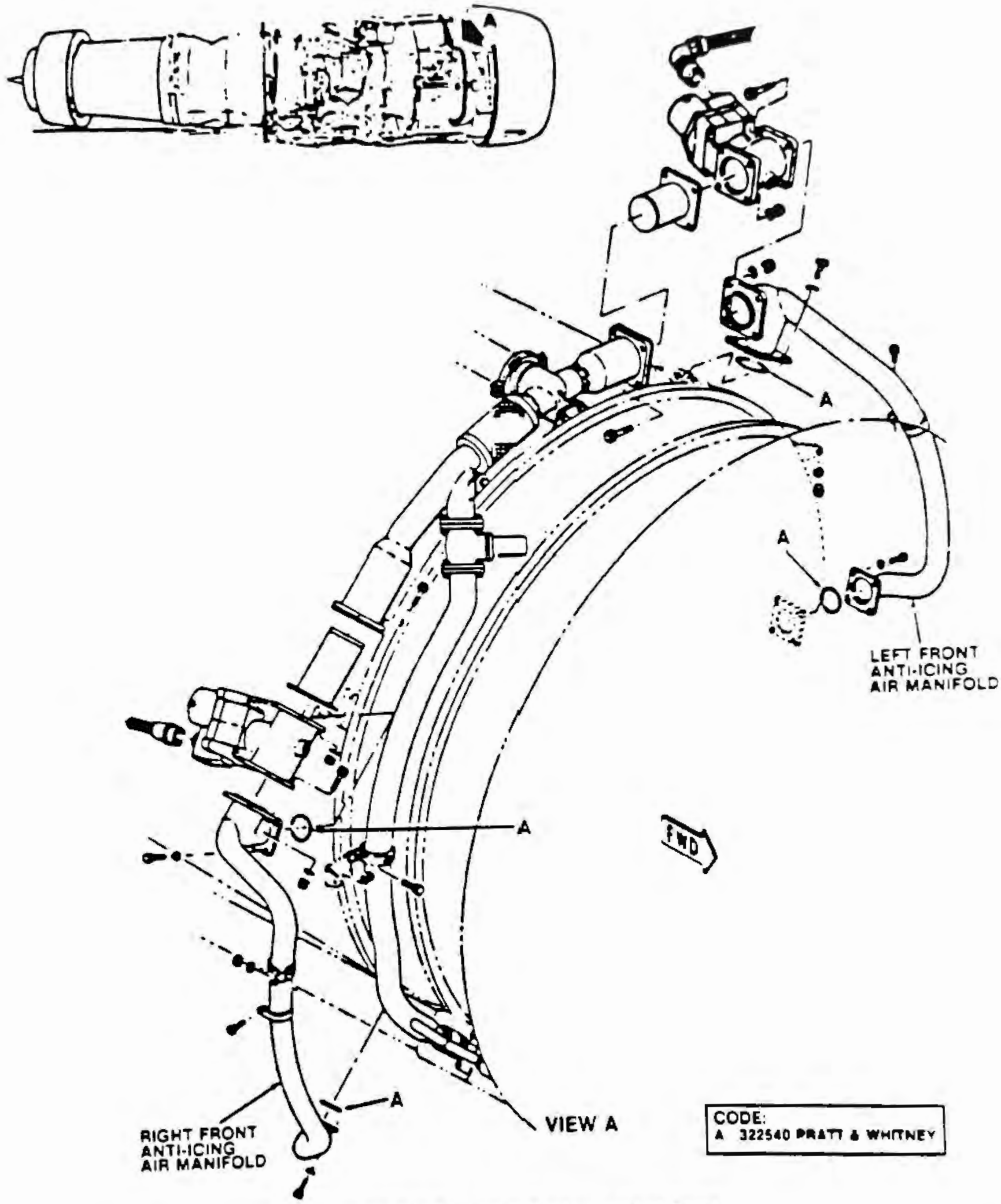
(3) The engine anti-icing system consists of the following components:

- (a) Anti-icing control switch
- (b) Indicating lights
- (c) Anti-icing air shutoff valves
- (d) Anti-icing air regulators

(4) The engine anti-icing control switches, one for each engine, provide common control for the engines. The engine anti-icing switches are toggle switches, located on the overhead switch panel in the flight compartment.

(5) The indicating lights, one for each engine, provide visual indication of anti-icing air shutoff valve operation. The lights are located on the overhead switch panel in the flight compartment.

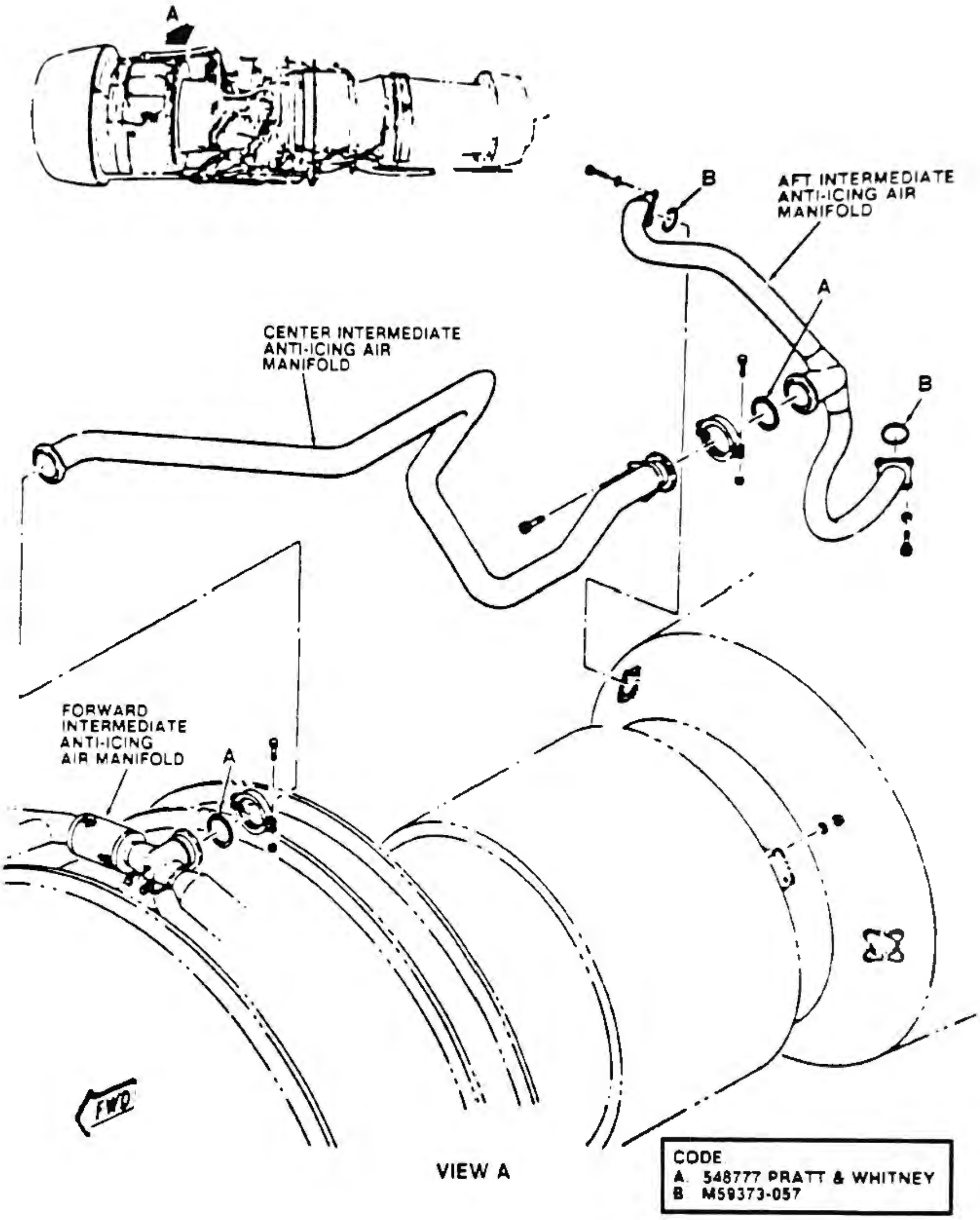
(6) The anti-icing air shutoff valves (See Figures 30-22 & 30-23) control the flow of bleed air utilized for anti-icing purposes. The valves are electrically operated, butterfly-type shutoff valves, equipped with integral limit and position indicating switches. An external position indicator provides visual means of determining the position of the butterfly at the valve. The engine valves are located on each side of the engine and are installed in the anti-icing air ducts. The nose cowl valve is located on the upper right side of the engine between the nose cowl anti-icing aft air duct and the nose cowl ice protection duct.



GENERAL PACKING LOCATION

FTX80531

Figure 30-22

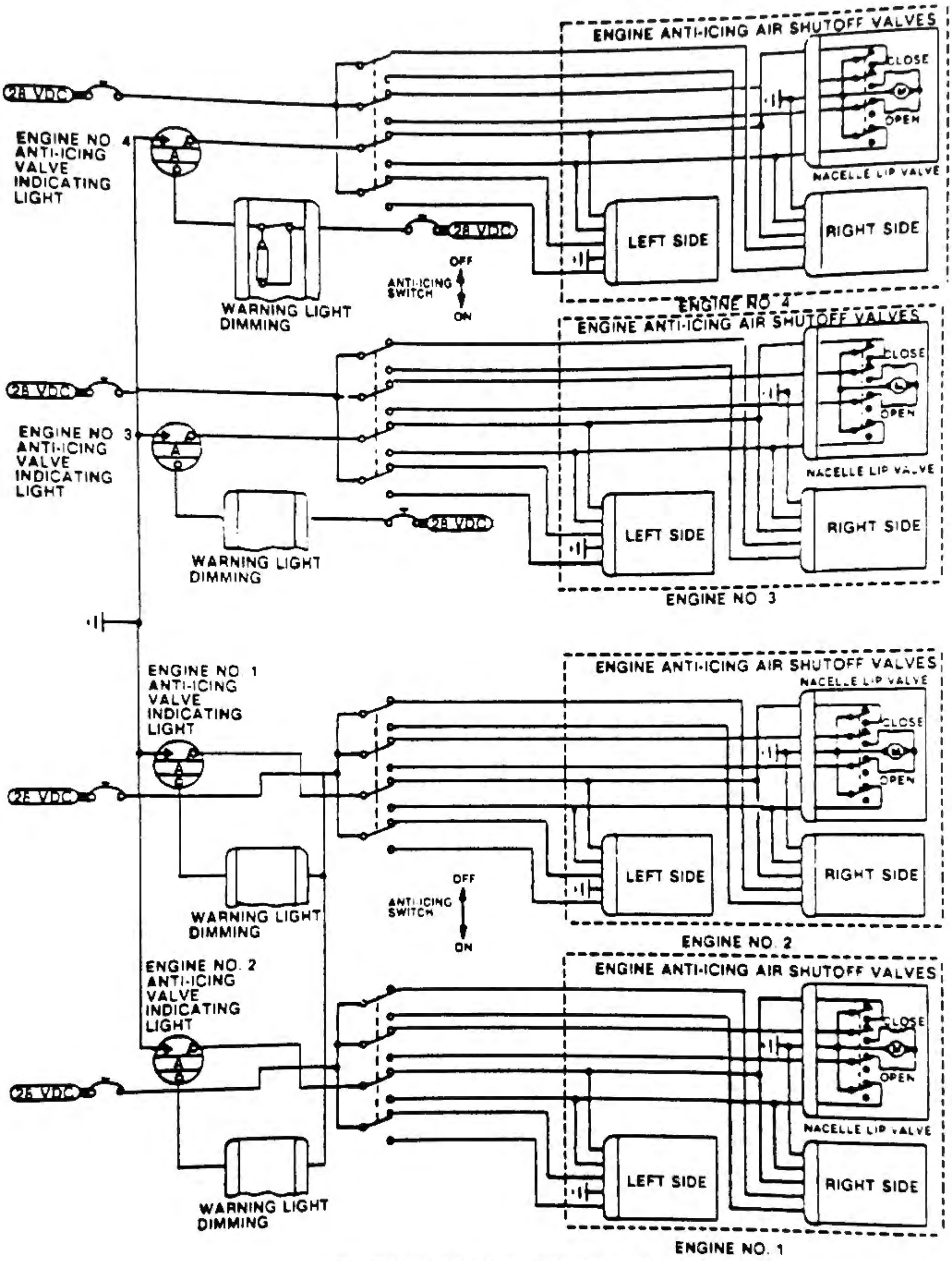

A
B
AFT INTERMEDIATE ANTI-ICING AIR MANIFOLD
A
CENTER INTERMEDIATE ANTI-ICING AIR MANIFOLD
B
FORWARD INTERMEDIATE ANTI-ICING AIR MANIFOLD
A
FWD
VIEW A
CODE
A. 548777 PRATT & WHITNEY
B. M59373-057

GENERAL PACKING LOCATION

FTX80532

Figure 30-23

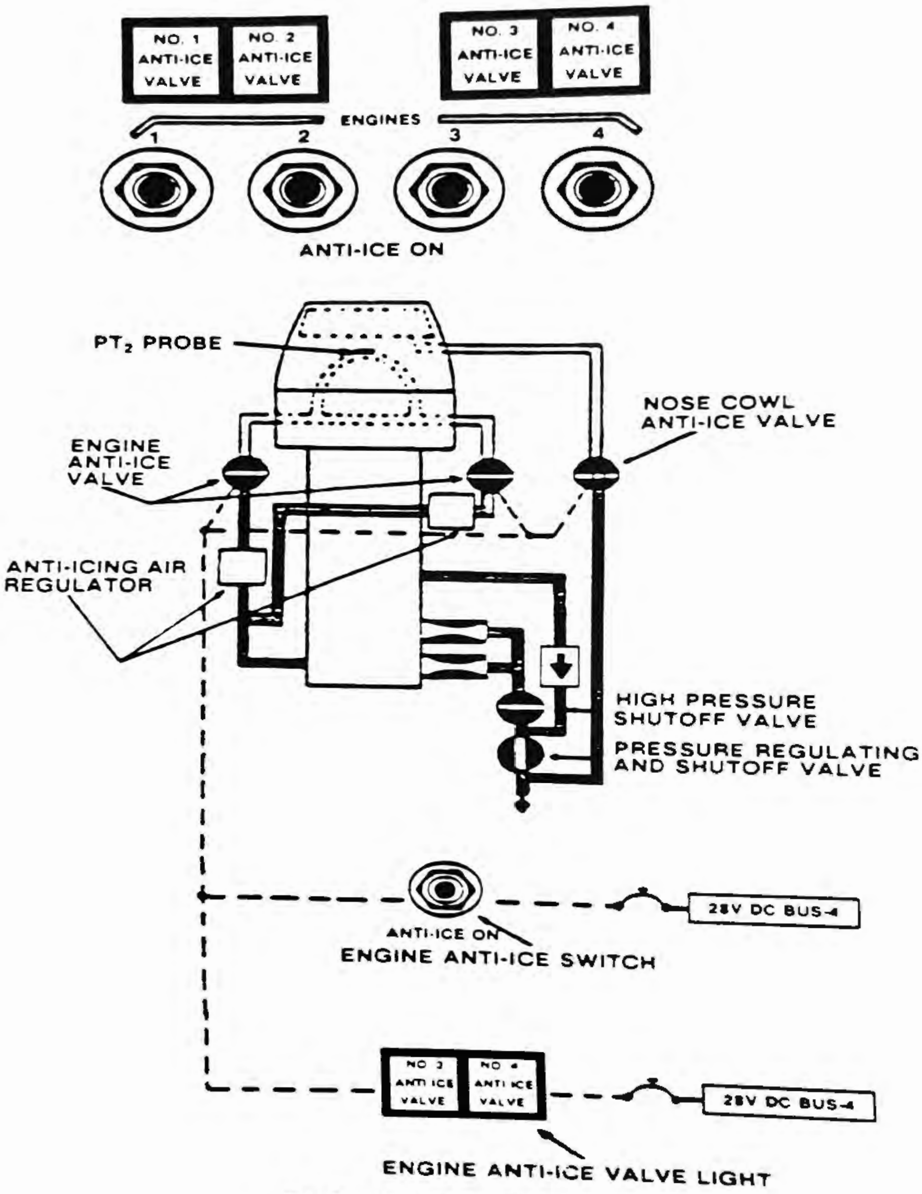
(6) To terminate operation, the anti-icing control switch is placed in the off position. The indicating light momentarily comes on as the engine valves move off their limit and position indicating switches. The indicating light then goes off as all valves move in response to control switch position. If the engine valves fail to move, the indicating light remains on. When the anti-icing control switch is in the off position and all valves are closed, the indicating light is off.



ENGINE ANTI-ICING SYSTEM

FTX80533

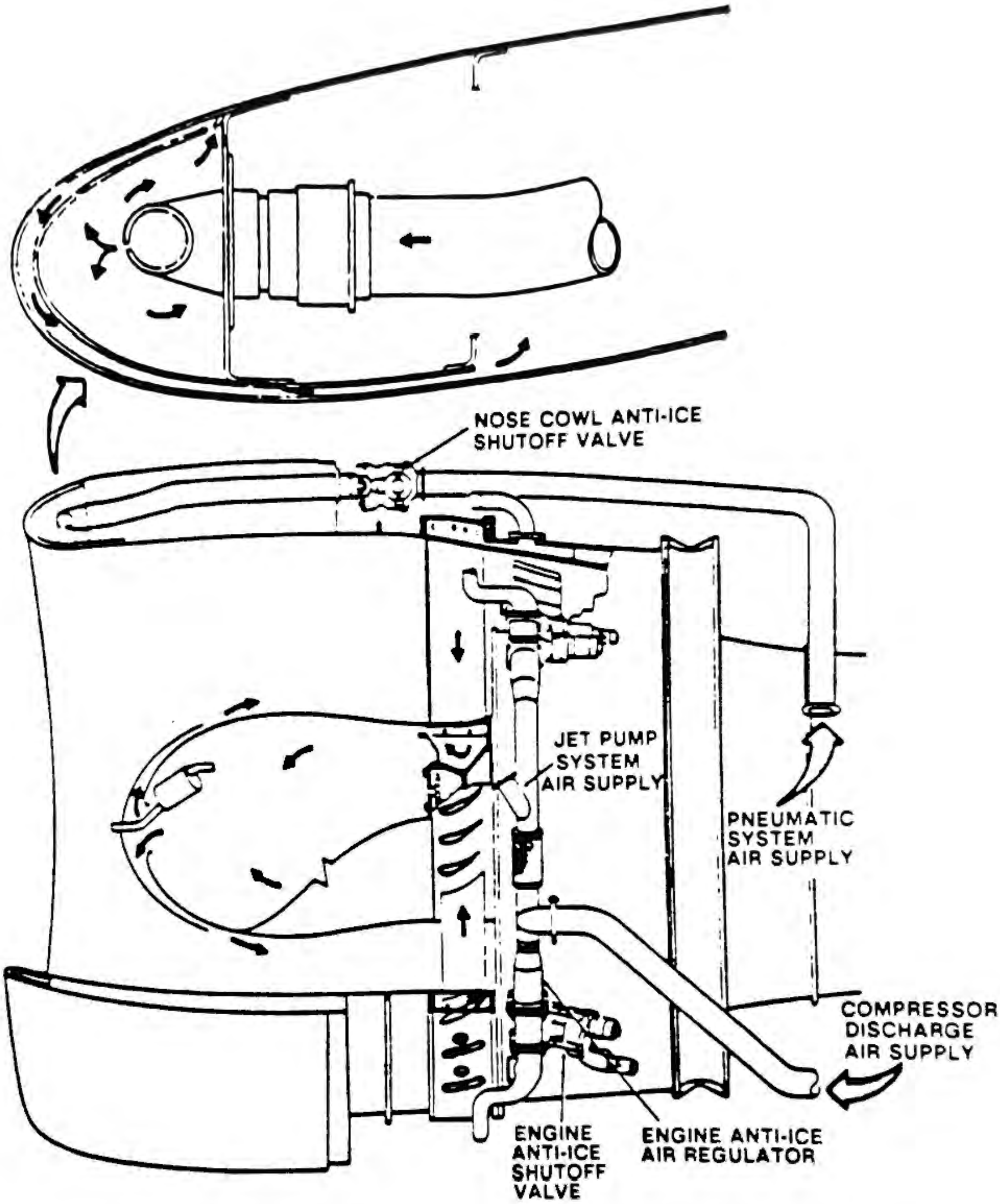
Figure 30-24



ENGINE ANTI-ICE

Figure 30-25

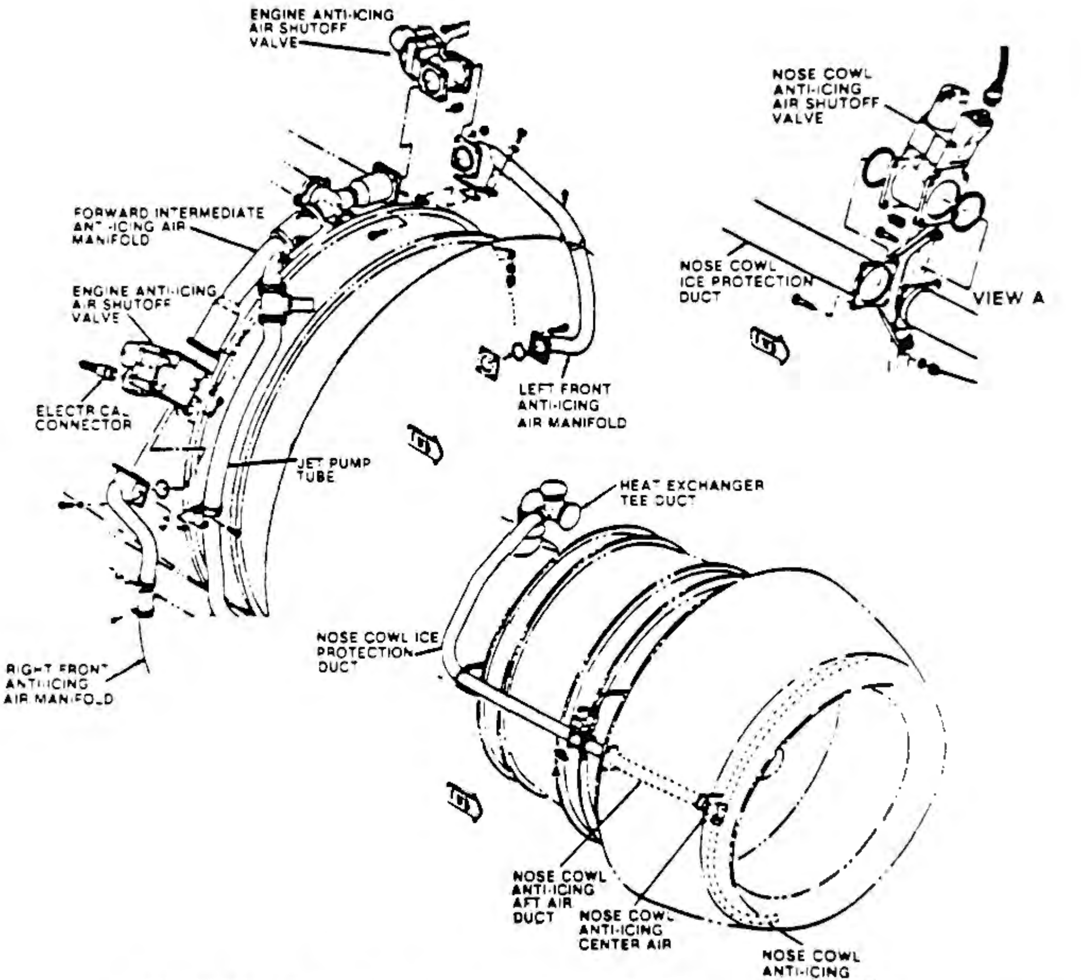
FTX80534


NOSE COWL ANTI-ICE SHUTOFF VALVE
JET PUMP SYSTEM AIR SUPPLY
PNEUMATIC SYSTEM AIR SUPPLY
COMPRESSOR DISCHARGE AIR SUPPLY
ENGINE ANTI-ICE SHUTOFF VALVE
ENGINE ANTI-ICE AIR REGULATOR

ENGINE AND NOSE COWL ANTI-ICING AIRFLOW SCHEMATIC

FTX80535

Figure 30-26


ENGINE ANTI-ICING AIR SHUTOFF VALVE
FORWARD INTERMEDIATE ANTI-ICING AIR MANIFOLD
ENGINE ANTI-ICING AIR SHUTOFF VALVE
ELECTRICAL CONNECTOR
JET PUMP TUBE
RIGHT FRONT ANTI-ICING AIR MANIFOLD
LEFT FRONT ANTI-ICING AIR MANIFOLD
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE
NOSE COWL ICE PROTECTION DUCT
VIEW A
HEAT EXCHANGER TEE DUCT
NOSE COWL ICE PROTECTION DUCT
NOSE COWL ANTI-ICING AFT AIR DUCT
NOSE COWL ANTI-ICING CENTER AIR
NOSE COWL ANTI-ICING FORWARD AIR DUCT

ENGINE ANTI-ICING AIR SHUTOFF VALVES

FTX80536

Figure 30-27

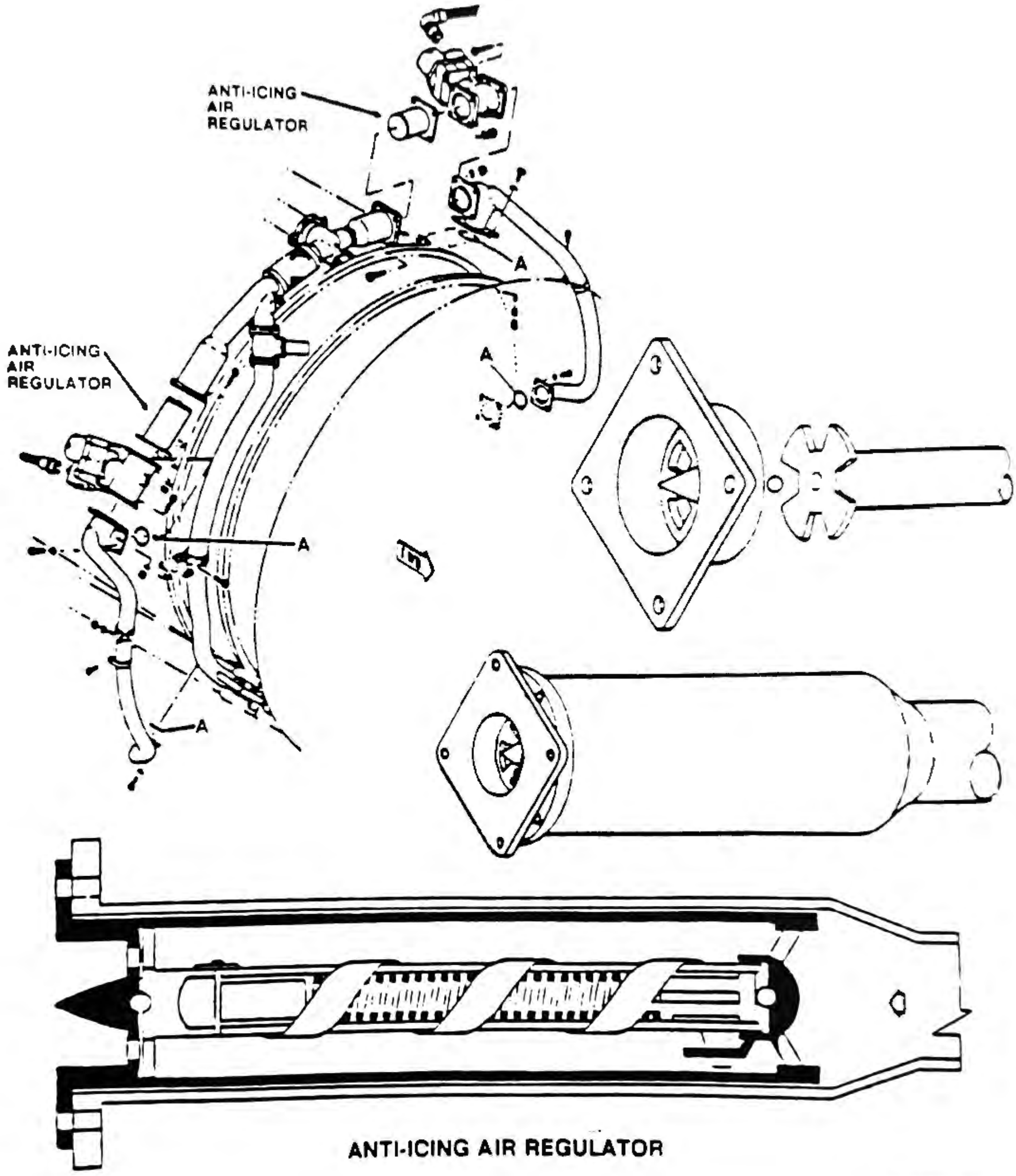

ANTI-ICING AIR REGULATOR
ANTI-ICING AIR REGULATOR
A
A
A
A
ANTI-ICING AIR REGULATOR
FTX80537

Figure 30-28

11. Indicating - Description and Operation

A. General

The engine and nose cowl indicating system provides visual indication of anti-icing air shutoff valve operation. The system consists of valves, indicating lights, and control switches. The engine anti-icing valves are located on each side of the engine. The nose cowl anti-icing is located on the upper right side of each engine nose cowl. The indicating lights, one for each engine, are located in the flight compartment. The control switches, one for inboard engines and one for outboard engines, are located in the flight compartment.

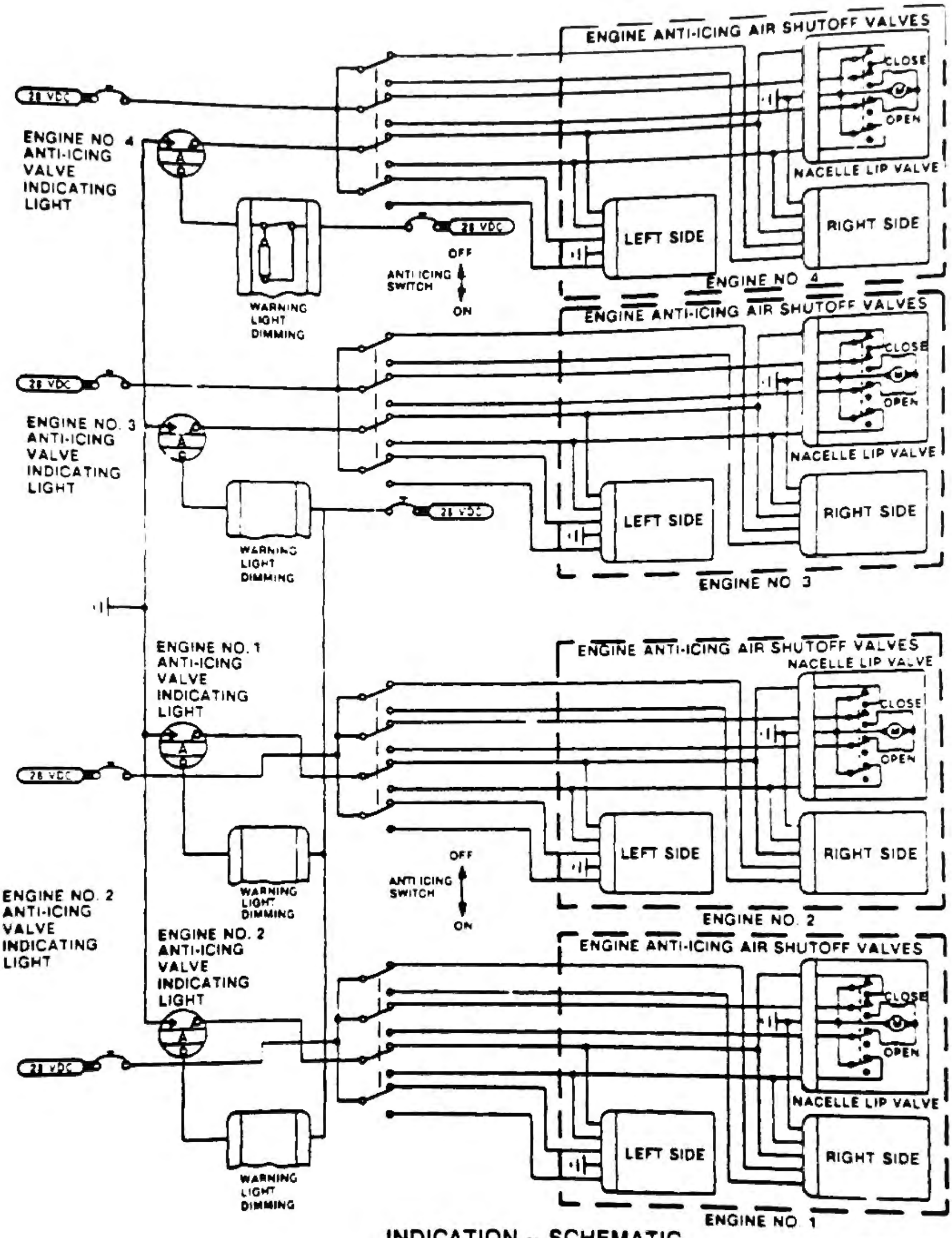
B. Operation (See Figure 30-29)

(1) Engine and Nose Cowl Indicating System

(a) Placing the anti-icing control switch in the anti-ice position initiates operation. A circuit is completed from a DC bus, through a circuit breaker and the control switch, to the anti-icing air shutoff valves.

(b) At the same time, the engine anti-icing switch arms one of the two indicating light limit and position indicating switches in each valve actuator. As the valves move, these switches open the indicating light circuit. The light comes on momentarily when the anti-icing control switch is moved to a new position. As the valves move in response to control switch position, their limit and position indicating switches open the circuit and the light goes off. If the valves fail to respond to switch position, the light will remain on, indicating a valve malfunction.

(c) To stop operation of engine and nose cowl indicating system, the anti-icing control switch is placed in the off position. The indicating light momentarily comes on as the valves move off their limit and position indication switches, and then goes off as all valves move in response to control switch position. If the valves fail to move in response to control switch position, the indicating light remains on. If the anti- icing control switch is in the off position and all valves are closed, the indicating light is off.


ENGINE ANTI-ICING AIR SHUTOFF VALVES
CLOSE
OPEN
NACELLE LIP VALVE
LEFT SIDE
RIGHT SIDE
ENGINE NO. 4
ENGINE NO. 3
ENGINE NO. 2
ENGINE NO. 1
28 VDC
ENGINE NO. 4 ANTI-ICING VALVE INDICATING LIGHT
ENGINE NO. 3 ANTI-ICING VALVE INDICATING LIGHT
ENGINE NO. 1 ANTI-ICING VALVE INDICATING LIGHT
ENGINE NO. 2 ANTI-ICING VALVE INDICATING LIGHT
WARNING LIGHT DIMMING
OFF
ANTI ICING SWITCH
ON
A
B
C

INDICATION -- SCHEMATIC
Figure 30-29

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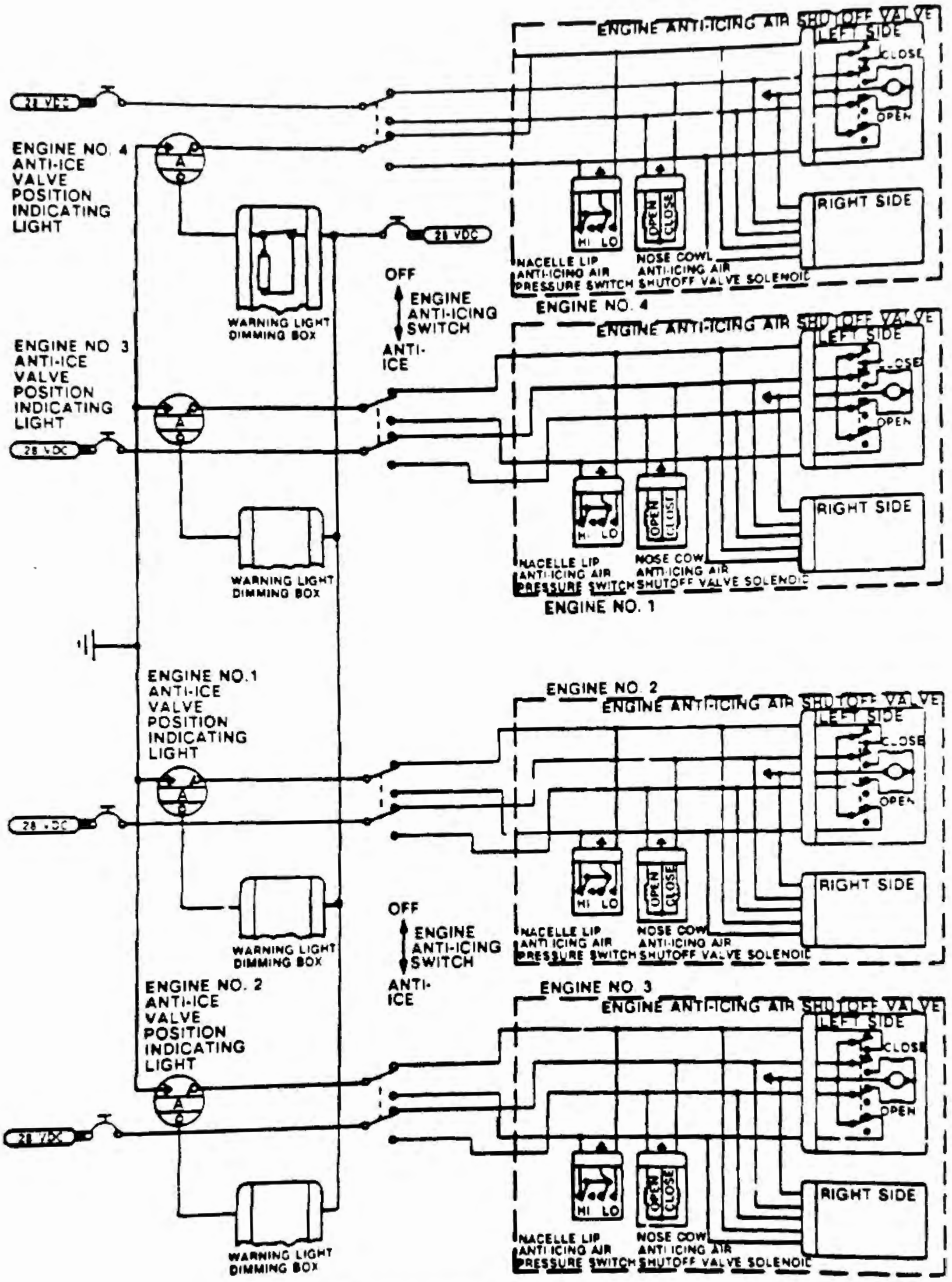
-61 DIFFERENCES

1. General - Description and Operation

A. Description

The engine anti-icing system utilizes compressor bleed air to anti-ice the inlet guide vanes and inlet bullet, and low- pressure pneumatic air to anti-ice the nose cowl leading edge.


28 VDC
ENGINE NO. 4 ANTI-ICE VALVE POSITION INDICATING LIGHT
WARNING LIGHT DIMMING BOX
28 VDC
OFF
ENGINE ANTI-ICING SWITCH
ANTI-ICE
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
ENGINE NO. 4
ENGINE NO. 3 ANTI-ICE VALVE POSITION INDICATING LIGHT
28 VDC
WARNING LIGHT DIMMING BOX
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
ENGINE NO. 1
ENGINE NO. 1 ANTI-ICE VALVE POSITION INDICATING LIGHT
28 VDC
WARNING LIGHT DIMMING BOX
OFF
ENGINE ANTI-ICING SWITCH
ANTI-ICE
ENGINE NO. 2
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
ENGINE NO. 2 ANTI-ICE VALVE POSITION INDICATING LIGHT
28 VDC
WARNING LIGHT DIMMING BOX
ENGINE NO. 3
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID

GENERAL SCHEMATIC

FTX80539

Figure 30-30

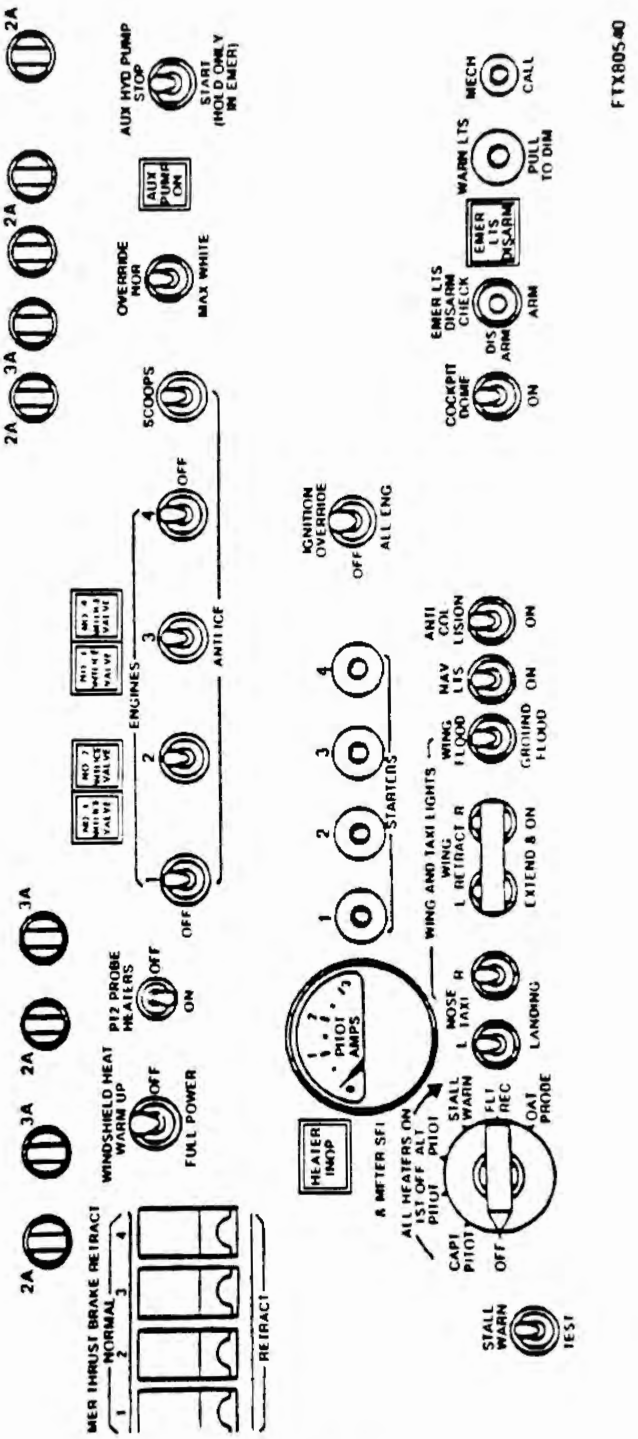
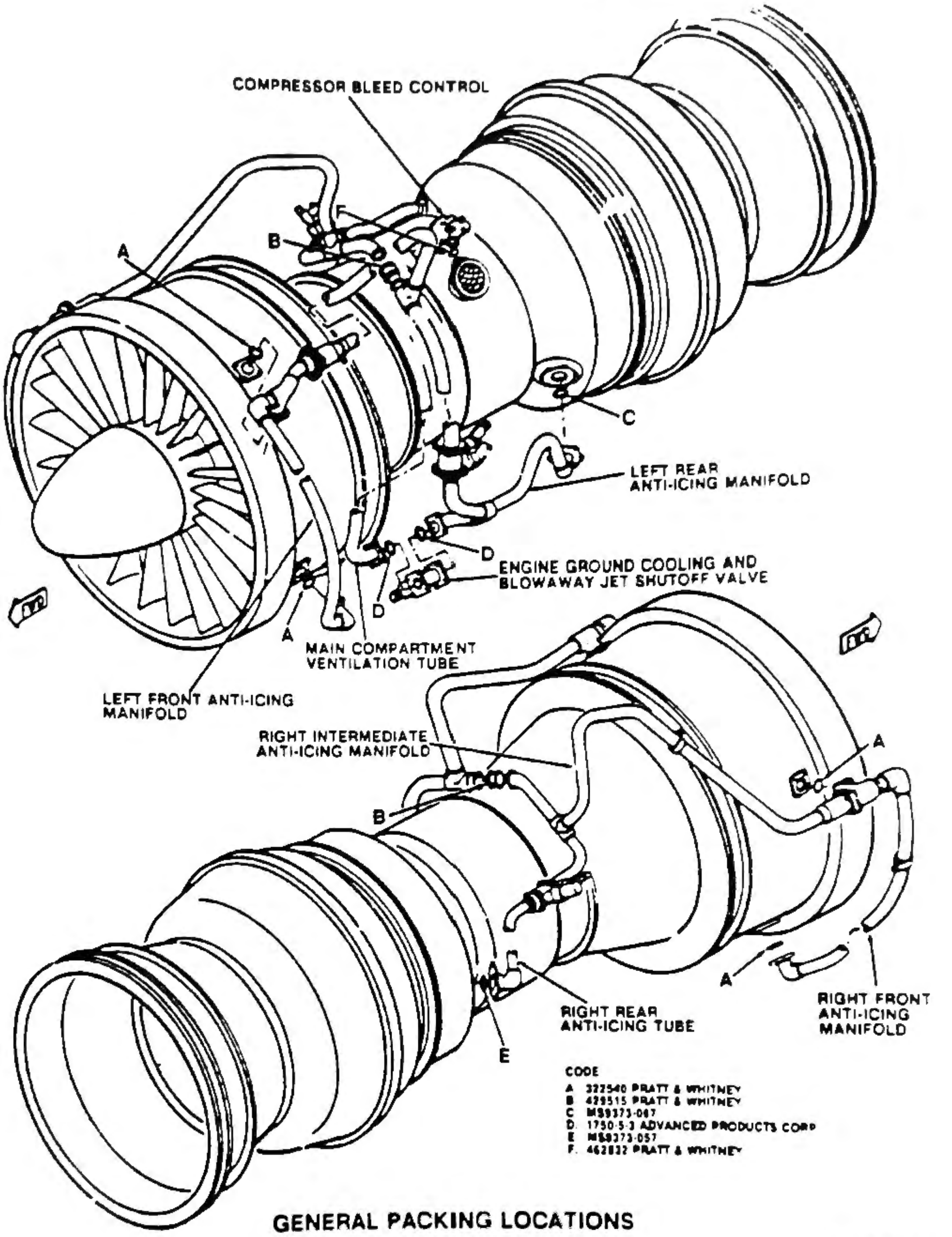

2A
3A
2A
3A
2A
3A
2A
2A
MER THRUST BRAKE RETRACT
NORMAL
1
2
3
4
RETRACT
WINDSHIELD HEAT
WARM UP
OFF
FULL POWER
PT2 PROBE
HEATERS
OFF
ON
NO 1 ANTI ICE VALVE
NO 2 ANTI ICE VALVE
NO 3 ANTI ICE VALVE
NO 4 ANTI ICE VALVE
ENGINES
1
2
3
4
OFF
OFF
ANTI ICE
SCOOPS
OVERRIDE
NOR
MAX WHITE
AUX PUMP ON
AUX HYD PUMP
STOP
START
(HOLD ONLY
IN EMER)
HEATER INOP
PITOT AMPS
A METER SEL
ALL HEATERS ON
1ST OFF
ALT PITOT
CAPT PITOT
STALL WARN
OFF
FLT REC
OAT PROBE
1
2
3
4
STARTERS
IGNITION
OVERRIDE
OFF
ALL ENG
STALL
WARN
TEST
WING AND TAXI LIGHTS
NOSE
L
TAXI
R
LANDING
WING
L RETRACT R
EXTEND & ON
WING
FLOOD
GROUND
FLOOD
NAV
LTS
ON
ANTI
COL-
LISION
ON
COCKPIT
DOME
ON
EMER LTS
DISARM
CHECK
DIS
ARM
ARM
EMER
LTS
DISARM
WARN LTS
PULL
TO DIM
MECH
CALL
FTX80540

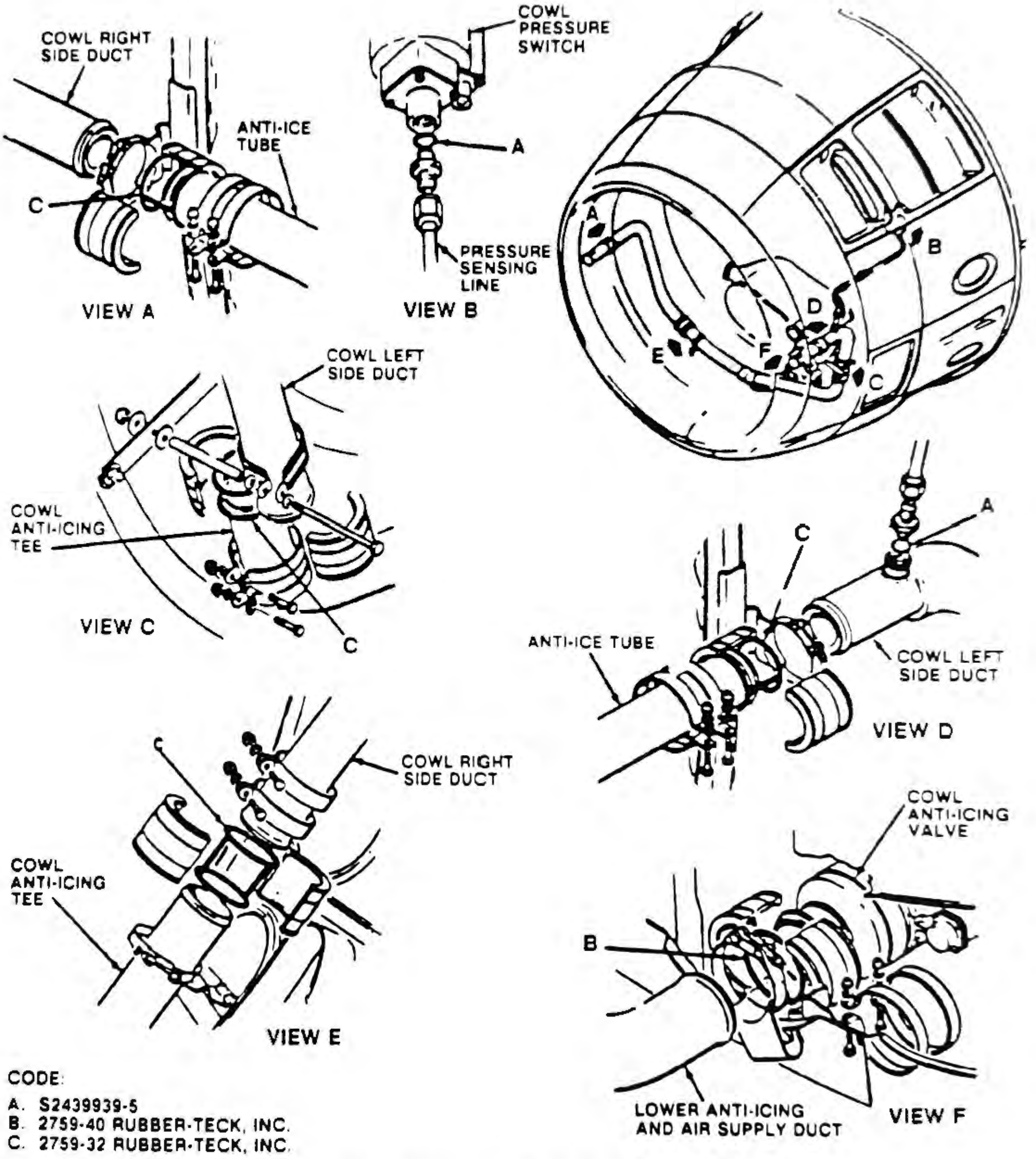
Figure 30-31


COMPRESSOR BLEED CONTROL
F
B
A
C
LEFT REAR ANTI-ICING MANIFOLD
D
ENGINE GROUND COOLING AND BLOWAWAY JET SHUTOFF VALVE
D
A
MAIN COMPARTMENT VENTILATION TUBE
LEFT FRONT ANTI-ICING MANIFOLD
RIGHT INTERMEDIATE ANTI-ICING MANIFOLD
B
A
A
RIGHT REAR ANTI-ICING TUBE
RIGHT FRONT ANTI-ICING MANIFOLD
E
CODE
A 322540 PRATT & WHITNEY
B 429515 PRATT & WHITNEY
C MS9373-067
D. 1750-5-3 ADVANCED PRODUCTS CORP
E MS9373-057
F. 462832 PRATT & WHITNEY

GENERAL PACKING LOCATIONS

FTX80541

Figure 30-32



GENERAL -- PACKING LOCATION

FTX80542

Figure 30-33

2. Engine Anti-Icing - Description and Operation

A. General

(1) Engine anti-icing prevents ice formation on the compressor inlet guide vanes, inlet bullet, and nose cowl leading edge.

(2) Engine and inlet bullet anti-icing air is provided by air obtained from the compressor bleed air manifold. Nose cowl anti-icing is provided by air obtained from the low-pressure pneumatic system.

(3) The engine anti-icing system consists of the following components:

(a) Anti-icing control switch

(b) Indicating lights

(c) Anti-icing air shutoff valves

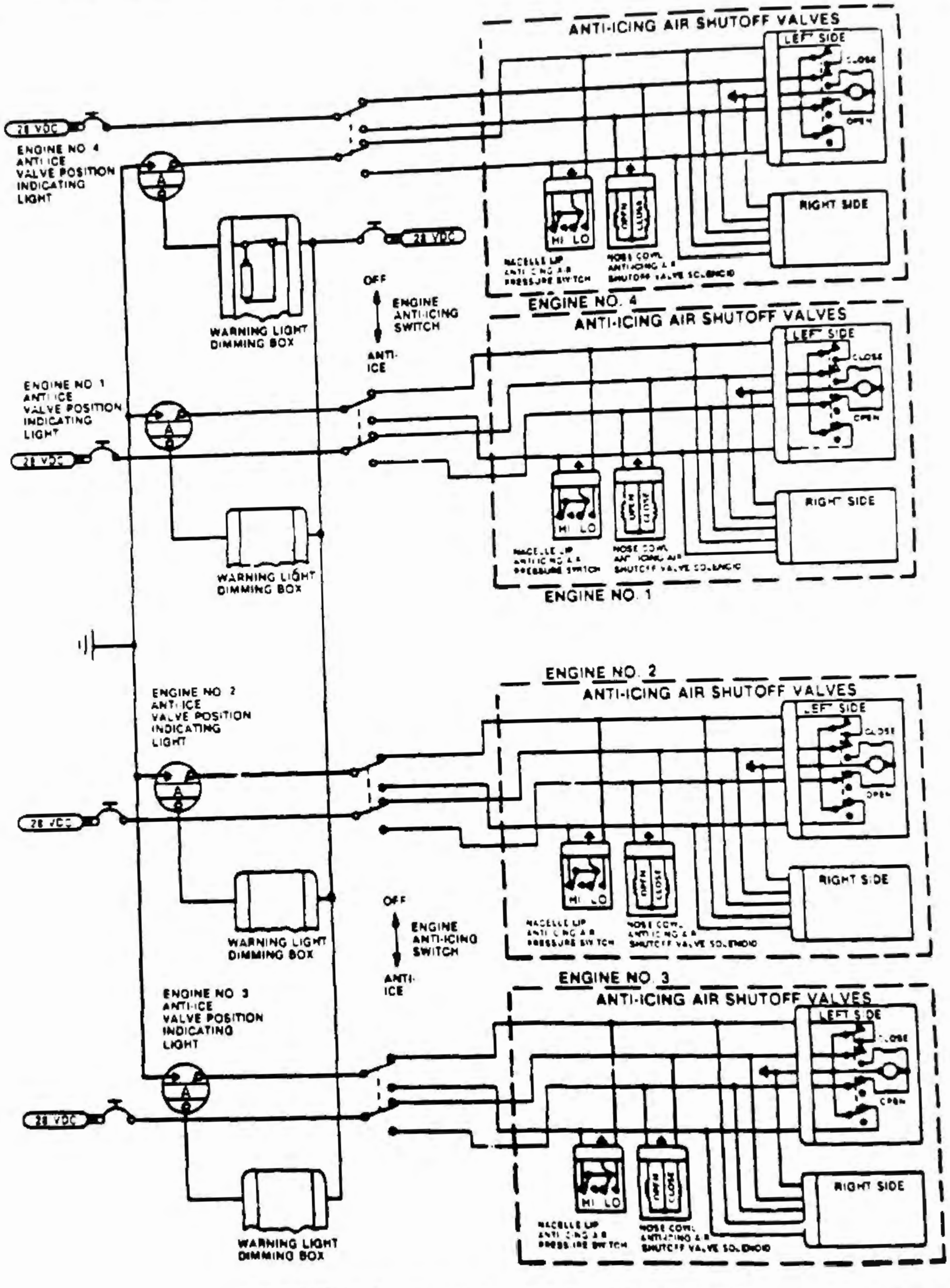
(d) Anti-icing air regulators

(e) Nacelle Lip Anti-Icing Air pressure switch

(4) Four engine anti-icing control switches, one for each engine provides control for engine anti-ice. The engine anti-icing switches are toggle switches, located on the overhead switch panel in the flight compartment.

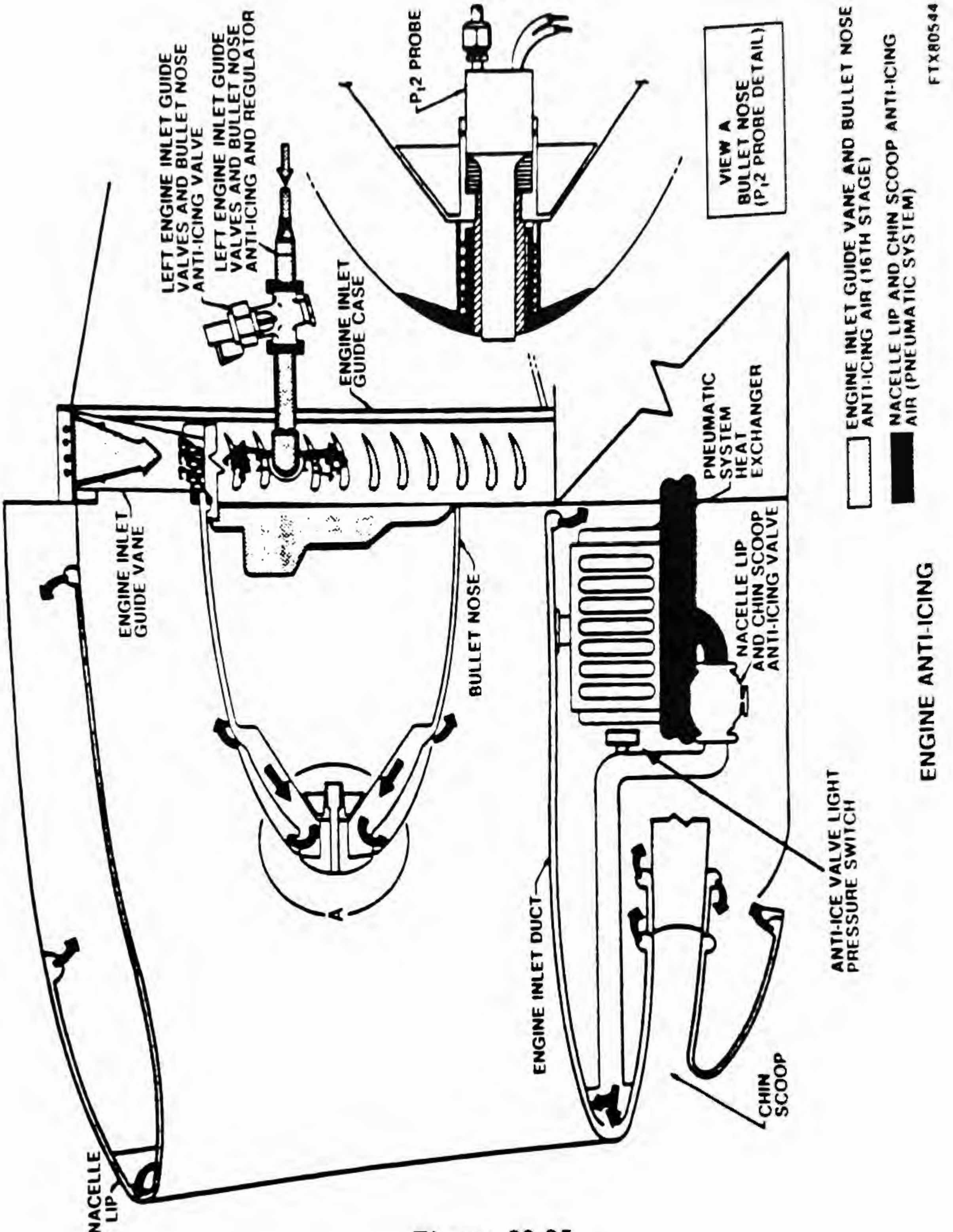
(5) The indicating lights, one for each engine, provide visual indication of anti-icing air shutoff valve operation. The lights are located on the overhead switch panel in the flight compartment.

(6) The anti-icing air shutoff valves control the flow of bleed air utilized for anti-icing purposes. The engines valves are electrically operated, butterfly-type shutoff valves, equipped with integral limit and position indicating switches. An external position indicator provides visual means of determining the position of the butterfly at the valve. The valves are located on each side of the engine and are installed in the anti-icing air ducts. The nose cowl valve is solenoid controlled and pressure actuated. The valve is located between the engine bleed air heat exchanger outlet header and the nose cowl leading edge.


ANTI-ICING AIR SHUTOFF VALVES
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
28 VDC
ENGINE NO 4 ANTI ICE VALVE POSITION INDICATING LIGHT
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
WARNING LIGHT DIMMING BOX
OFF
ENGINE ANTI-ICING SWITCH
ANTI-ICE
ENGINE NO. 4
ENGINE NO 1 ANTI ICE VALVE POSITION INDICATING LIGHT
ENGINE NO. 1
ENGINE NO. 2
ENGINE NO 2 ANTI-ICE VALVE POSITION INDICATING LIGHT
ENGINE NO 3 ANTI-ICE VALVE POSITION INDICATING LIGHT
ENGINE NO. 3

ENGINE ANTI-ICING SYSTEM -- SCHEMATIC FTX80543

Figure 30-34


NACELLE LIP
ENGINE INLET GUIDE VANE
LEFT ENGINE INLET GUIDE VALVES AND BULLET NOSE ANTI-ICING VALVE
LEFT ENGINE INLET GUIDE VALVES AND BULLET NOSE ANTI-ICING AND REGULATOR
ENGINE INLET GUIDE CASE
P$_t$2 PROBE
A
BULLET NOSE
ENGINE INLET DUCT
VIEW A
BULLET NOSE
(P$_t$2 PROBE DETAIL)
PNEUMATIC SYSTEM HEAT EXCHANGER
NACELLE LIP AND CHIN SCOOP ANTI-ICING VALVE
CHIN SCOOP
ANTI-ICE VALVE LIGHT PRESSURE SWITCH
ENGINE INLET GUIDE VANE AND BULLET NOSE ANTI-ICING AIR (16TH STAGE)
NACELLE LIP AND CHIN SCOOP ANTI-ICING AIR (PNEUMATIC SYSTEM)
FTX80544

ENGINE ANTI-ICING

Figure 30-35

(7) The engine anti-icing air regulators control the flow of anti-icing air supplied to the engine outlet. The air regulators are located on each side of the engine between the air shutoff valves and the compressor inlet case.

(8) The pressure switch, located in the cowl duct, senses duct pressure downstream from the cowl anti-icing valve.

(9) The pressure switch is actuated by a spring-loaded arm, which is moved by a pressure diaphragm assembly within the switch. One set of contacts will close if a low-pressure condition exists, and the other set of contacts will close if a high-pressure condition exists. If the pressure is increased, the low-pressure contacts will close a 3 psi, and the high-pressure contacts will open at 15 psi. If the pressure is decreased, the high-pressure contacts will close at 13 psi, and the low-pressure contacts will open at 1 psi.

(10) The engine Pt2 inlet pressure probe anti-icing system controls ice accumulation around the Pt2 probes. The system consists of a heating element in each Pt2 probe and a control switch on the overhead panel. The probes are energized whenever the aircraft buses are energized and the control switch is in the ON position.

B. Operation

(1) To initiate operation, the anti-icing control switch is placed in the anti-ice position and the following sequence of events occurs:

(a) A circuit is completed from a DC bus, through a circuit breaker and the control switch, to the anti-icing air shutoff valves.

(b) At the same time, the engine anti-icing switch arms one of two indicating light limit and position indicating switches in each engine valve actuator. As the engine valves move, these switches open the indicating light circuit. The light comes on momentarily when the engine anti-icing control switch is moved to a new position. As the valves move in response to control switch position, the limit and position indicating switch opens the circuit and the light goes off. If the valve fails to move, the light remains on, indicating an engine valve malfunction.

(c) The indicating light circuit is also energized by the nacelle lip anti-icing air pressure switch if the nose cowl anti-icing valve fails to respond to the control switch position. The pressure switch contacts close, energizing the indicating light circuit. The indicating light comes on, indicating a malfunction of the nose cowl anti-icing valve. In addition, if the pressure downstream of the nose cowl valve falls below 13 psig, the pressure switch contract close and the indicating light comes on.

(d) As the engine anti-icing valves open, hot compressed air flows through the anti-icing valve and air regulator, through the system tubes, into continuous manifold ring of the engine inlet case. The ring encircles the engine inlet guide vanes, the outer end of which connect to the ring. The inner end of each vane connects to the inlet bullet. Airflow continues through the ring into the hollow cavities in the guide vanes and inlet bullet and exhausts into the engine inlet stream.

(e) At the same time that the engine anti-icing valves open, the nose cowl anti-icing valve opens. This permits air from the pneumatic manifold to anti-ice the nose cowl and pneumatic heat exchanger air inlet scoop.

(f) Anti-icing air from the nose cowl anti-icing valve flows through the D-duct, flows into the oil cooler and the bleed air heat exchanger inlet scoop, and exhausts overboard.

(g) As air temperature increases, the air regulator valve moves to the closed position, limiting airflow to the engine inlet. As air temperature decreases, the valve moves to the open position and increases the flow of air. The air regulator valve modulates between open and close, supplying anti-icing air.

(2) To cease operation, the anti-icing control switch is placed in the off position. The indicating light momentarily comes on as the engine valves move off their limit and position indicating switches. The indicating light then goes off as all valves move in response to control switch position. If the engine valves fail to move, the indicating light remains on. If the cowl valve fails to fully close and pressure downstream of the valve rises to 3 psi, the pressure switch contacts close, the indicating light comes on. If the anti-icing control switch is in the off position and all valves are closed, the indicating light is off.

3. Indicating - Description and Operation

A. General

The engine and nose cowl indicating system provides visual indication of anti-icing air shutoff valve operation. The system consists of valves, indicating lights, pressure switches and control switches. The engine anti-icing valves are located on each side of the engine. The nose cowl anti-icing valve is located on the left side of each engine nose cowl, and a pressure-actuated switch is located downstream of the nose cowl valve. The indicating lights, one for each engine, are located in the flight compartment. The control switches, one for each engine are located in the flight compartment.

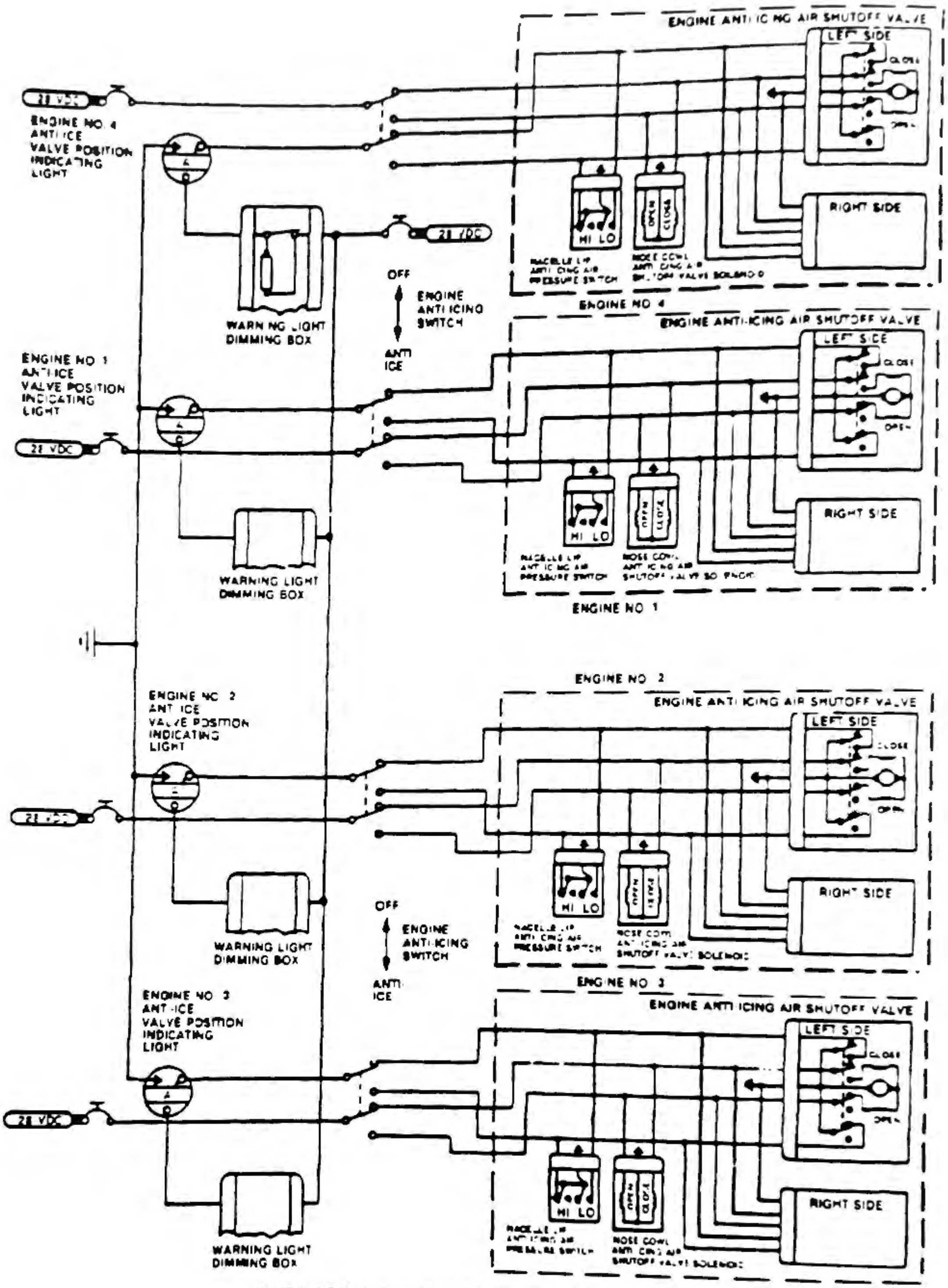
B. Operation

(1) Engine and Nose Cowl Indicating System

(a) Placing the anti-icing control switch in the anti-ice position initiates operation. A circuit is completed from a DC bus, through a circuit breaker and the control switch, to the anti-icing air shutoff valves.

(b) At the same time, the engine anti-icing switch arms one of the two indicating light limit and position indicating switches in each engine valve actuator. As the engine valves move, these switches open the indicating light circuit. The light comes on momentarily when the engine anti-icing control switch is moved to a new position. As the valves move in response to control switch position, their limit and position indicating switches open the circuit and the light goes off. If the valves fail to respond to switch position, the light will remain on, indicating valve malfunction.

(c) If the cowl anti-icing valve fails to respond to the control switch position, the pressure switch contacts close, completing a circuit to the indicating light. The indicating light comes on, indicating a valve malfunction. If pressure downstream of the valve falls below 13 psig, the pressure switch contacts close, and the indicating light comes on.


ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
28 VDC
ENGINE NO. 4 ANTI-ICE VALVE POSITION INDICATING LIGHT
WARNING LIGHT DIMMING BOX
28 VDC
HI LO
OPEN CLOSE
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
ENGINE NO 4
OFF
ENGINE ANTI-ICING SWITCH
ANTI ICE
ENGINE NO 1 ANTI-ICE VALVE POSITION INDICATING LIGHT
28 VDC
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
RIGHT SIDE
HI LO
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
WARNING LIGHT DIMMING BOX
ENGINE NO 1
ENGINE NO 2
ENGINE NO 2 ANTI-ICE VALVE POSITION INDICATING LIGHT
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
28 VDC
RIGHT SIDE
HI LO
OFF
ENGINE ANTI-ICING SWITCH
ANTI ICE
WARNING LIGHT DIMMING BOX
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
ENGINE NO 3
ENGINE NO 3 ANTI-ICE VALVE POSITION INDICATING LIGHT
ENGINE ANTI-ICING AIR SHUTOFF VALVE
LEFT SIDE
CLOSE
OPEN
28 VDC
RIGHT SIDE
HI LO
NACELLE LIP ANTI-ICING AIR PRESSURE SWITCH
NOSE COWL ANTI-ICING AIR SHUTOFF VALVE SOLENOID
WARNING LIGHT DIMMING BOX

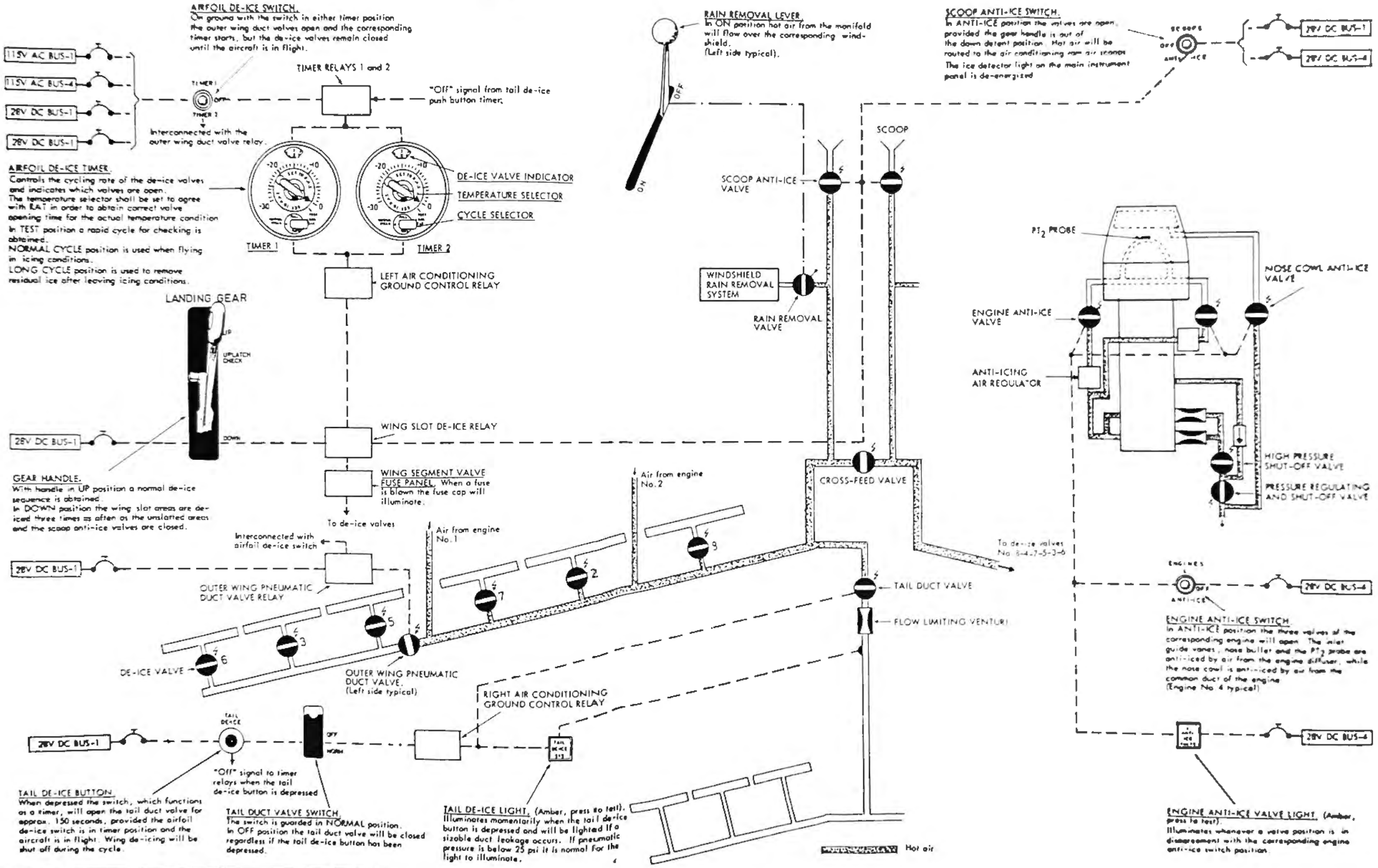
ANTI-ICE VALVE POSITION SCHEMATIC

FTX80545

Figure 30-36

(d) To stop operation of engine and nose cowl indicating system, the anti-icing control switch is placed in the off position. The indicating light momentarily comes on as the engine valves move off their limit and position indicating switches, and then goes off as all valves move in response to control switch position. If the engine valves fail to move in response to control switch position, the indicating light remains on. If the cowl valve fails to fully close and pressure rises to 3 psig downstream of the valve, the pressure switch contacts close, and the indicating light comes on. If the anti-icing control switch is in the off position and all valves are closed, the indicating light is off.

ICE AND RAIN PROTECTION
Description



AIRFOIL DE-ICE SWITCH.
On ground with the switch in either timer position the outer wing duct valves open and the corresponding timer starts, but the de-ice valves remain closed until the aircraft is in flight.

AIRFOIL DE-ICE TIMER.
Controls the cycling rate of the de-ice valves and indicates which valves are open.
The temperature selector shall be set to agree with RAT in order to obtain correct valve opening time for the actual temperature condition.
In TEST position a rapid cycle for checking is obtained.
NORMAL CYCLE position is used when flying in icing conditions.
LONG CYCLE position is used to remove residual ice after leaving icing conditions.

RAIN REMOVAL LEVER.
In ON position hot air from the manifold will flow over the corresponding windshield.
(Left side typical).

SCOOP ANTI-ICE SWITCH.
In ANTI-ICE position the valves are open, provided the gear handle is out of the down detent position. Hot air will be routed to the air conditioning ram air scoops.
The ice detector light on the main instrument panel is de-energized.

GEAR HANDLE.
With handle in UP position a normal de-ice sequence is obtained.
In DOWN position the wing slot areas are de-iced three times as often as the unslotted areas and the scoop anti-ice valves are closed.

WING SEGMENT VALVE FUSE PANEL. When a fuse is blown the fuse cap will illuminate.

"Off" signal from tail de-ice push button timer.

Interconnected with the outer wing duct valve relay.

Interconnected with airfoil de-ice switch

"Off" signal to timer relays when the tail de-ice button is depressed

TAIL DE-ICE BUTTON.
When depressed the switch, which functions as a timer, will open the tail duct valve for approx. 150 seconds, provided the airfoil de-ice switch is in timer position and the aircraft is in flight. Wing de-icing will be shut off during the cycle.

TAIL DUCT VALVE SWITCH.
The switch is guarded in NORMAL position.
In OFF position the tail duct valve will be closed regardless if the tail de-ice button has been depressed.

TAIL DE-ICE LIGHT. (Amber, press to test).
Illuminates momentarily when the tail de-ice button is depressed and will be lighted if a sizable duct leakage occurs. If pneumatic pressure is below 25 psi it is normal for the light to illuminate.

ENGINE ANTI-ICE SWITCH.
In ANTI-ICE position the three valves of the corresponding engine will open. The inlet guide vanes, nose bullet and the PT_2 probe are anti-iced by air from the engine diffuser, while the nose cowl is anti-iced by air from the common duct of the engine.
(Engine No. 4 typical)

ENGINE ANTI-ICE VALVE LIGHT. (Amber, press to test).
Illuminates whenever a valve position is in disagreement with the corresponding engine anti-ice switch position.

1. General - Description and Operation

A. Description (See Figure 32-1 & 32-2)

(1) The airplane has a tricycle-type, fully retractable landing gear. The nose gear is a dual-wheel, steerable oleo strut mounted in the forward, lower section of the fuselage. The main gear consists of two oleo struts, each supporting a bogie beam and four wheels and brakes, located in the wing root area aft of the right and left wing rear spar.

(2) The main gear bogie consists of a tubular beam which supports the two wheel and brake axles, one at each end of the beam. The bogie beam is held in a position perpendicular to the main gear strut by a hydraulic trim cylinder.

(3) The main gear inboard doors and the nose gear forward doors are connected to their respective gear through linkages and cables, which sequence the doors to the open position during gear travel and to the closed position at the end of each cycle. The nose gear aft doors and the main gear center and outboard doors are linked directly to the gear struts and move with the gear. Each wheel well is completely enclosed by doors when the gear is retracted, and the major portion of each wheel well is enclosed after the gear is extended.

(4) Gear retraction and extension and the mechanical release of latches are controlled by the landing gear control lever. The hydraulic power system actuates the gear, latches, bungee cylinders, and inboard doors. Without hydraulic power, the gear can be mechanically released to free-fall and mechanically locked in the down position.

(5) Each main gear wheel is fitted with a hydraulically powered disc brake. The brake system is actuated by the hydraulic power system and has an air system as backup which may be used in the event of a loss of hydraulic pressure. An electrically controlled antiskid system provides a locked-wheel protection feature and affords a maximum efficiency to the brake system.

(6) The nosewheel steering system is a hydraulically actuated and mechanically controlled means of steering the airplane through ground maneuvers.

(7) An electric indicating and warning system provides the flight crew with all the necessary gear and door position indications.

2. Main Gear and Doors - Description and Operation

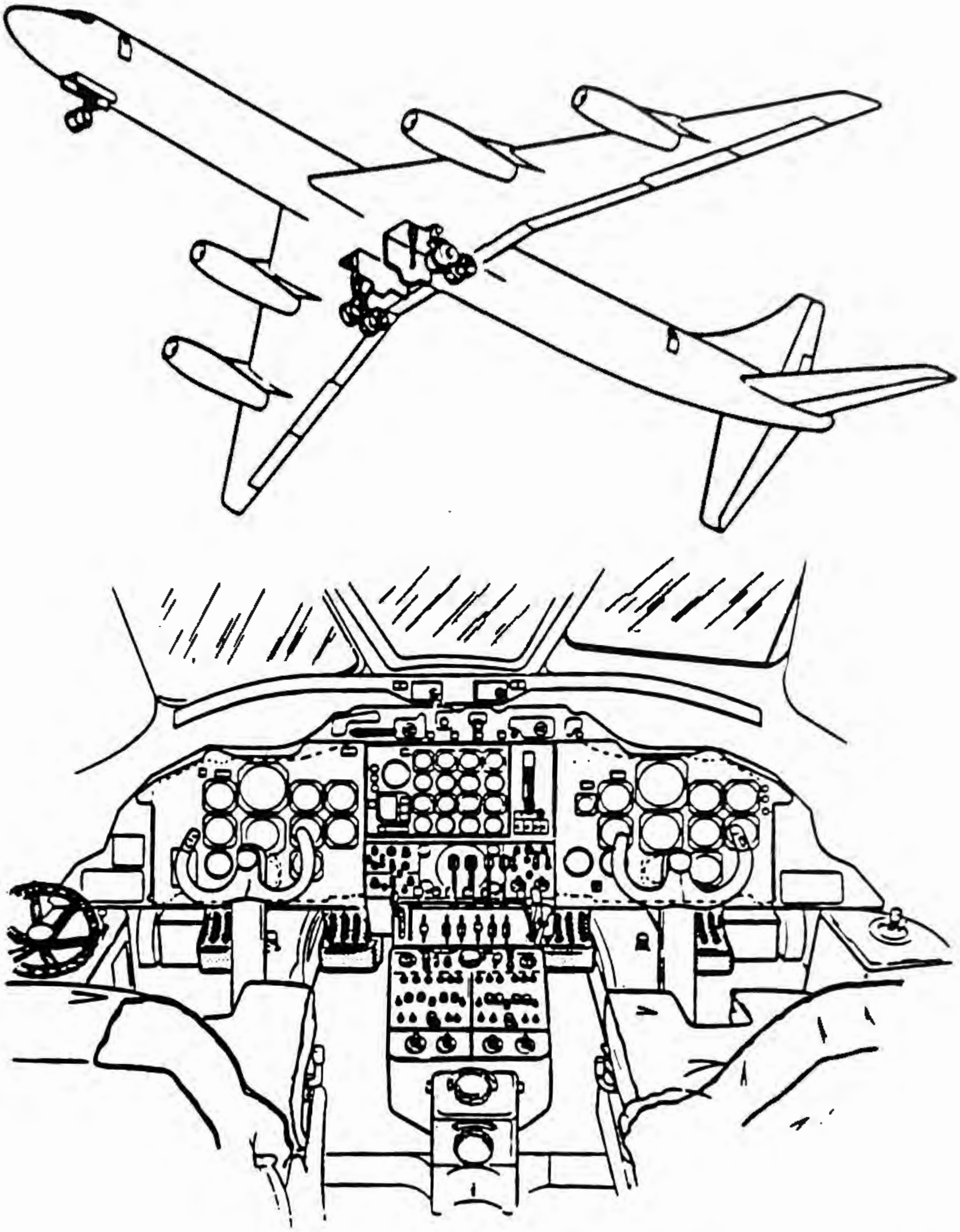
A. General (See Figure 32-3)

(1) Each main gear consists of a 4-wheel bogie attached to an oleo strut which is mounted on cantilevered support fittings on the rear spar in each wing root area. The main gear is moved approximately 90 degrees inboard and up, and the side braces fold up during gear retraction. The main gear is completely enclosed within the wheel wells during flight.

(2) Each main gear strut assembly consists of a conventional oleo shock strut with a bogie undercarriage and is supported laterally by side brace links. The links are locked in the down position by overcenter links that are driven hydraulically by the bungee cylinders and mechanically by the bungee springs. The side brace links and the overcenter links fold up along the struts during gear retraction.

(3) One large and two small doors enclose each wheel well when the gear is retracted. The inboard doors are sequenced to the open position during gear travel and are closed at both ends of the travel cycle. The center and outboard doors are linked to the gear strut and follow the strut at all times.

(4) The bogie beam assembly consists of a one-piece tubular support member that provides a platform for the forward and aft axles, wheels and brakes. The bogie pivot trunnion provides the attachment to the main gear strut, and allows the beam to pivot. The pivot action of the beam permits all tires to maintain contact with the ground when the airplane rides over uneven terrain, or when the airplane lands in a nose high attitude.



LANDING GEAR AND CONTROLS
Figure 32-1

FTX80101

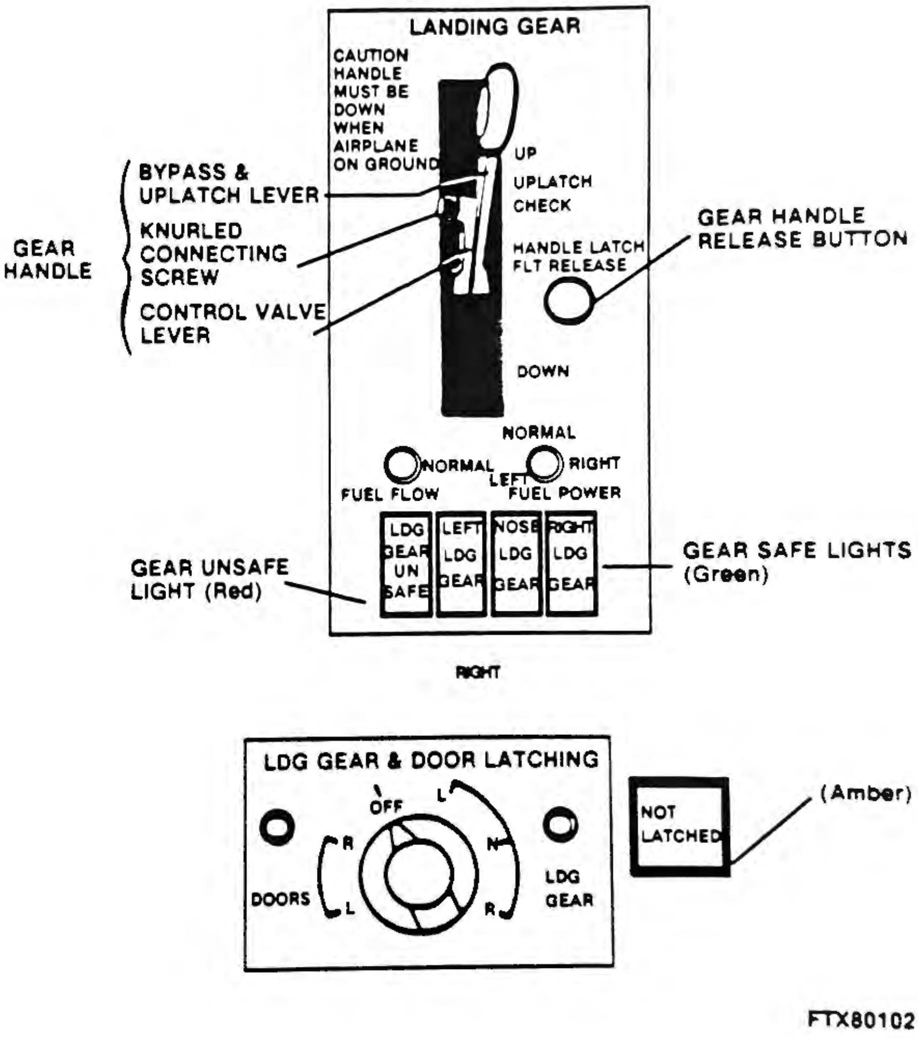
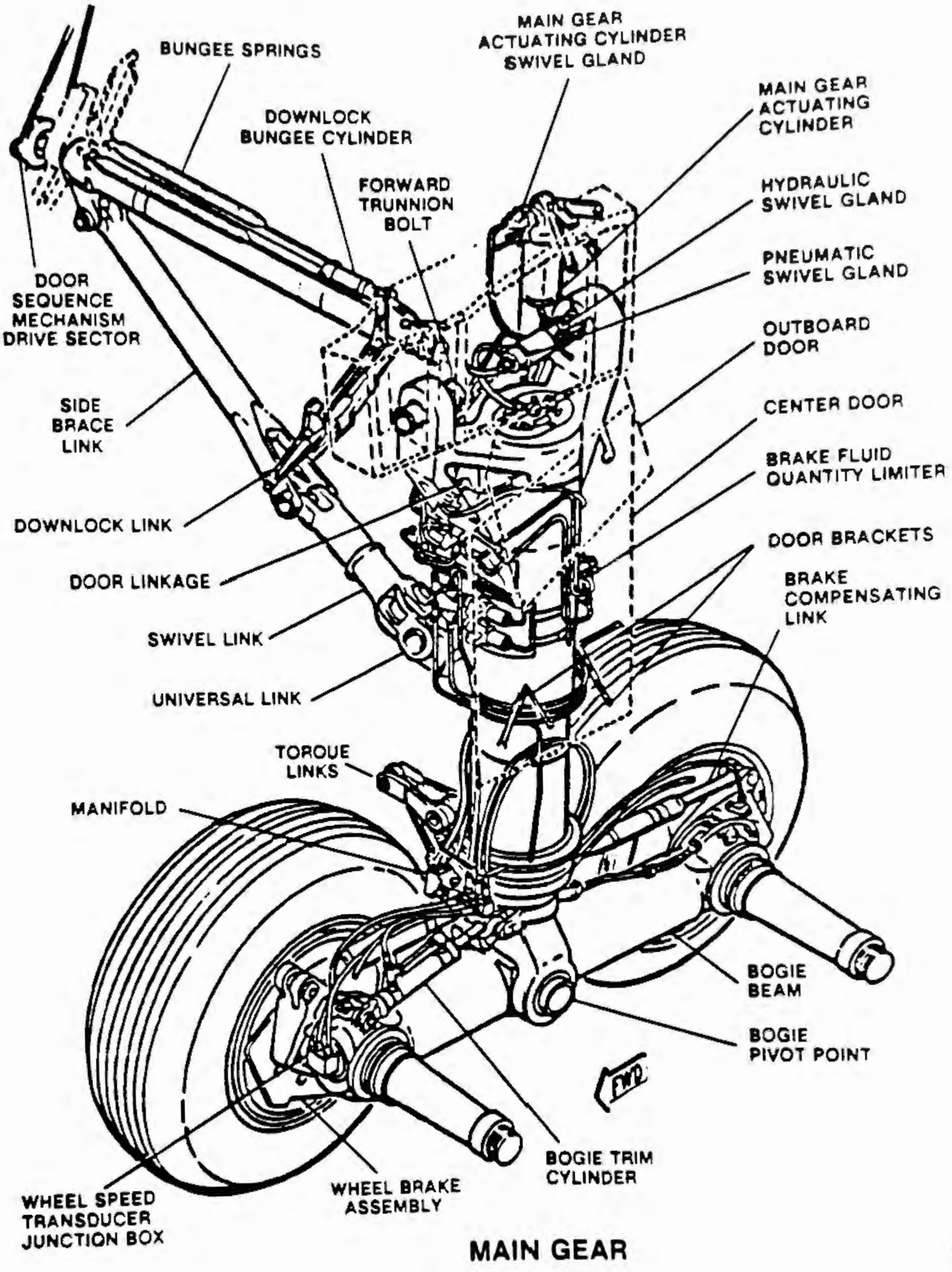

LANDING GEAR
CAUTION HANDLE MUST BE DOWN WHEN AIRPLANE ON GROUND
UP
UPLATCH CHECK
HANDLE LATCH FLT RELEASE
DOWN
GEAR HANDLE
BYPASS & UPLATCH LEVER
KNURLED CONNECTING SCREW
CONTROL VALVE LEVER
GEAR HANDLE RELEASE BUTTON
NORMAL
FUEL FLOW
NORMAL
LEFT
RIGHT
FUEL POWER
LDG GEAR UN SAFE
LEFT LDG GEAR
NOSE LDG GEAR
RIGHT LDG GEAR
GEAR UNSAFE LIGHT (Red)
GEAR SAFE LIGHTS (Green)
RIGHT
LDG GEAR & DOOR LATCHING
OFF
L
R
N
L
R
DOORS
LDG GEAR
NOT LATCHED
(Amber)
FTX80102

Figure 32-2



MAIN GEAR

Figure 32-3

B. Main Gear Struts (See Figure 32-4)

(1) The main gear struts support the weight of the airplane on an air and oil cushion, which absorbs landing shock. Internally, each shock strut contains a metering pin and orifice plate that dampens strut compression motion.

(2) Static and dynamic seals, located at the lower end of the strut, serve to retain the oil and air pressure inside the cylinder. A scraper and wiper are located above the gland nut and serve to clean the piston upon entry into the cylinder. The gland nut retains the seal bearings and piston inside the cylinder.

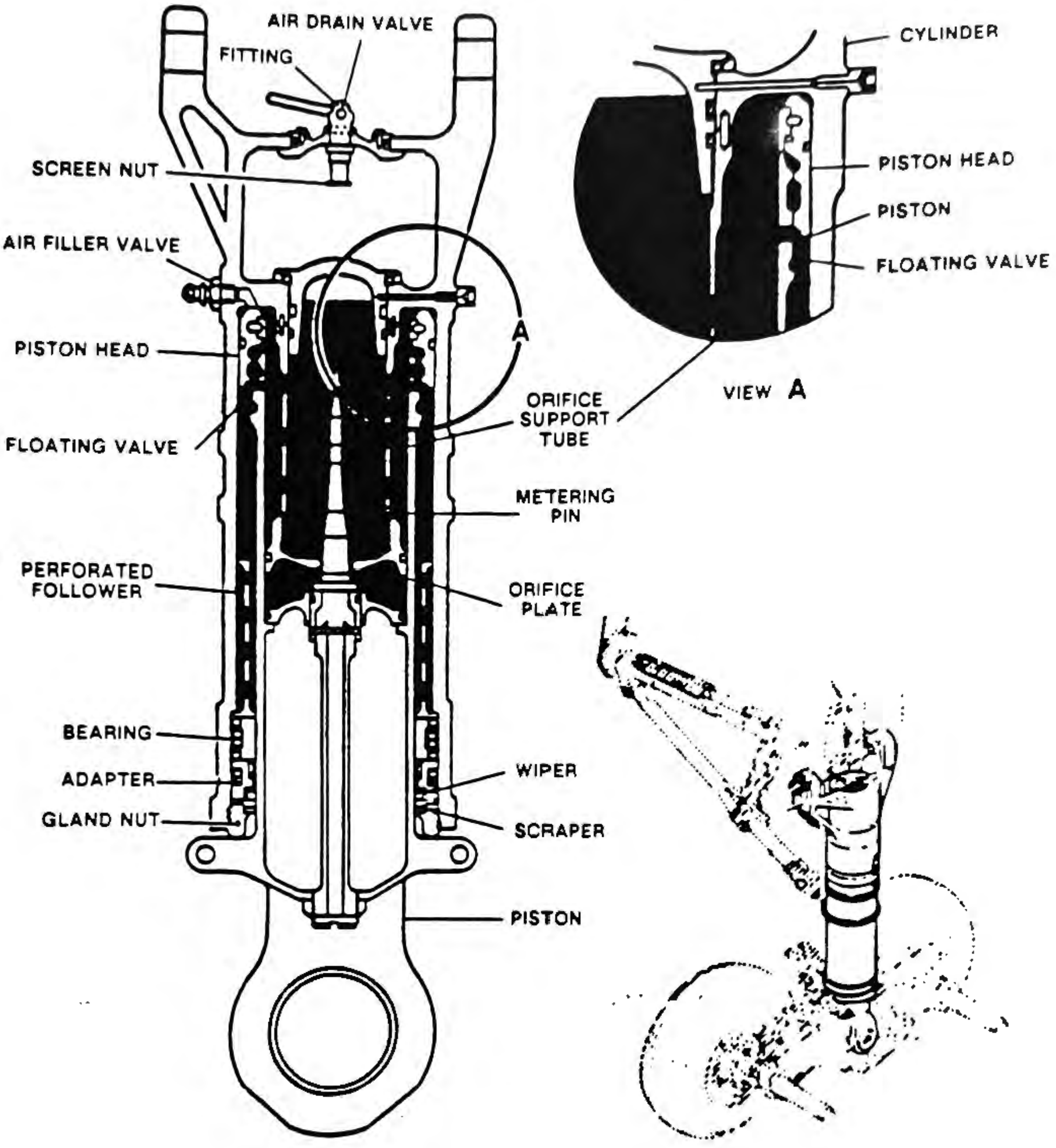
C. Main Gear Linkage (See Figure 32-5)

(1) The main gear linkage provides the means for supporting and locking the gear in the extended position. The linkage is installed on the forward and inboard side of each strut, and consists of three assemblies: the torque tube, side brace, and downlock links. The torque tube is a tubular member that spans the wheel well from the shear web to the landing gear support fitting and is the attach point for the side braces and the over-center links. The side brace links consist of three parts: upper link, swivel link, and universal link. The downlock links consist of four parts: two upper and two lower links with an actuator lever at the upper ends.

D. Main Gear Torque Links

(1) The main gear torque links are A-frame type heavy members used to connect the main gear strut cylinder to the piston assembly and to hold the piston in a fixed position rotationally.

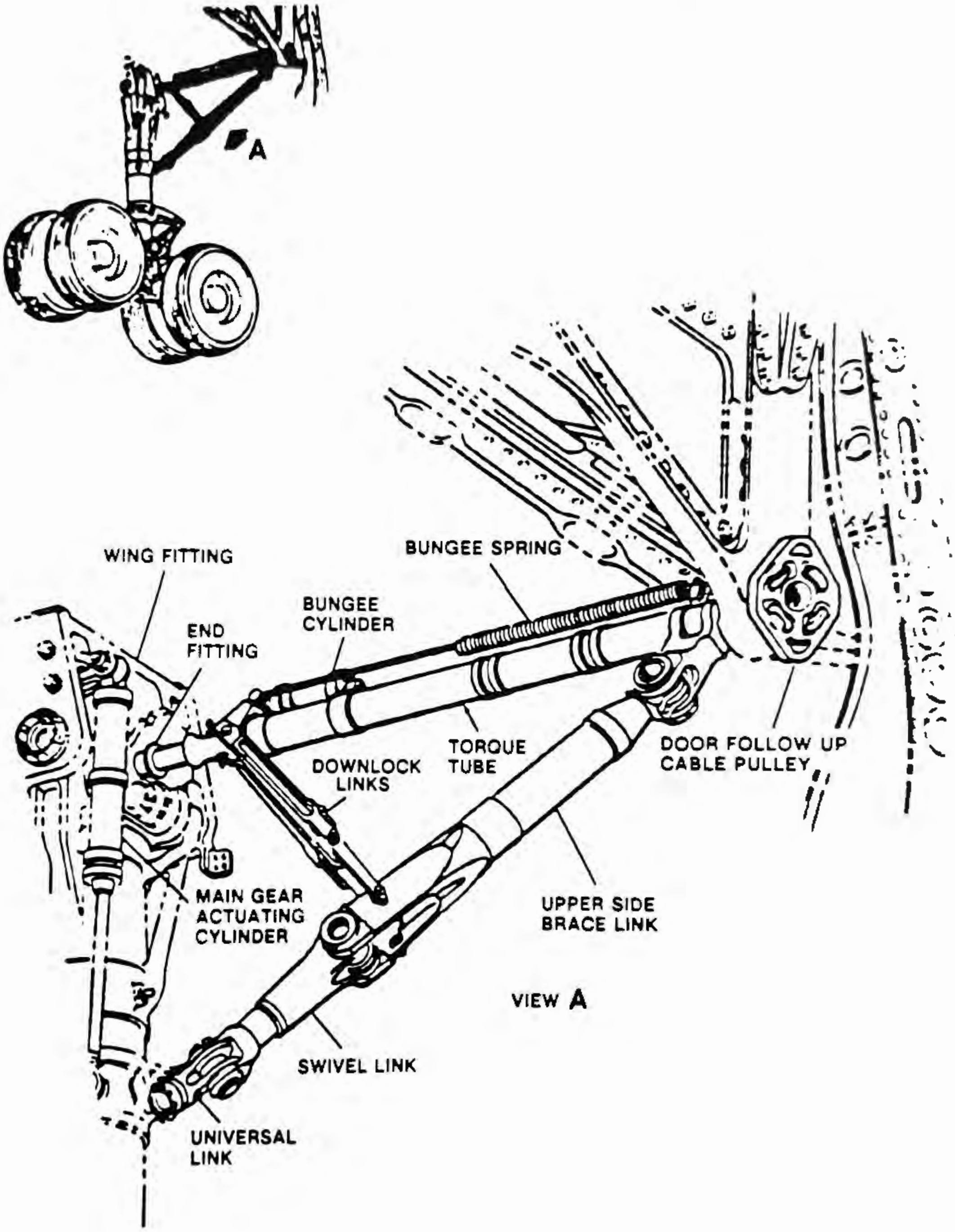
(2) The upper torque link is connected to a fitting on the lower inboard side of the shock strut cylinder, and the lower link is attached to a similar fitting on the piston. The upper and lower links are joined together by an apex bolt and nut.



MAIN GEAR STRUT -- CUTAWAY

FTX80104

Figure 32-4



MAIN GEAR LINKAGE

FTX80105

Figure 32-5

E. Main Gear Doors (See Figure 32-6)

(1) Each main gear wheel well is enclosed by three doors: the inboard door, hinged at the keel cap,the center door, attached to the gear strut; and the outboard door, hinged to the wing.

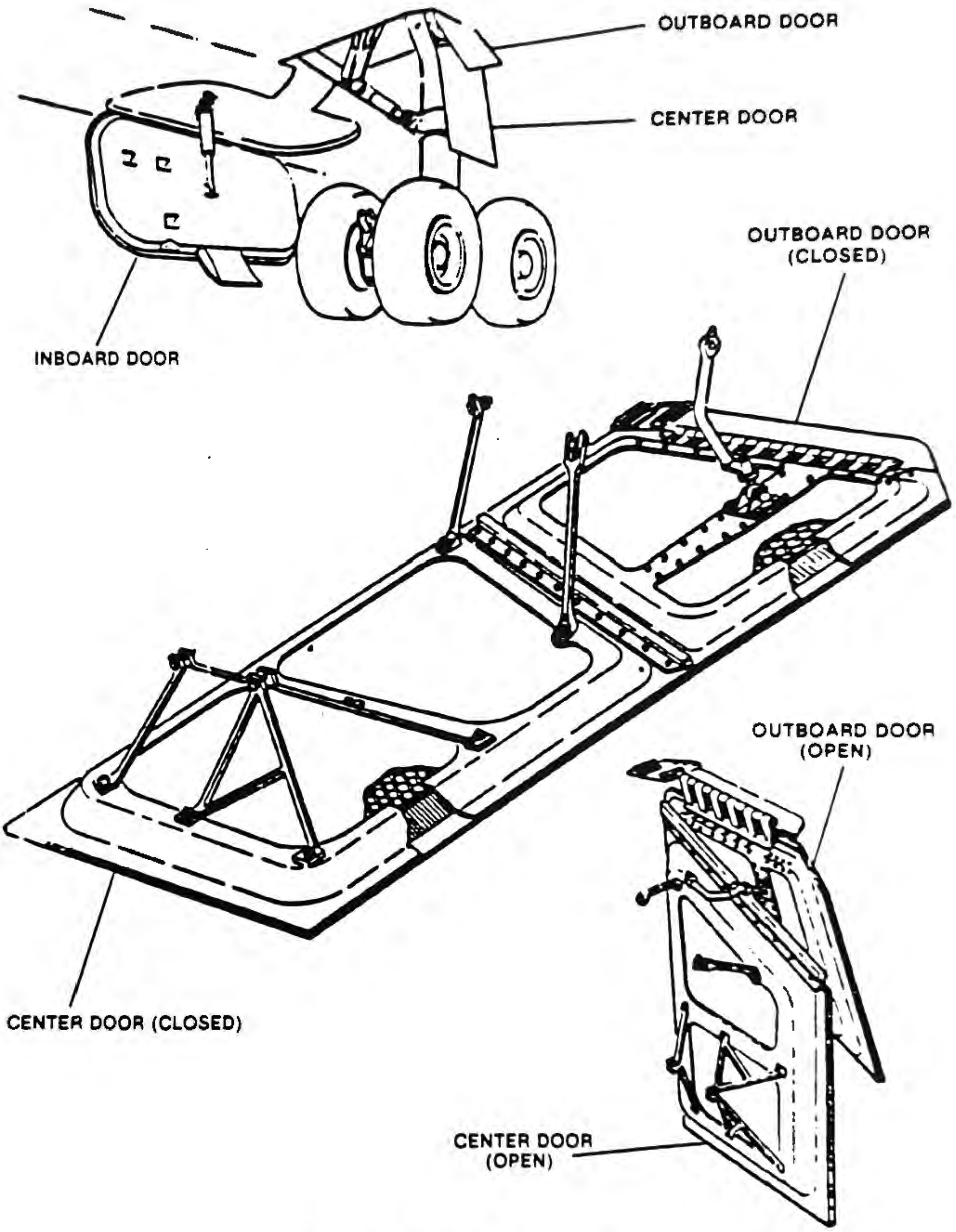
(2) The inboard door is the largest in size and is oval in shape, except for one rectangular protrusion at the outboard edge, which forms a wing to fuselage fillet when the door is closed. The center door is attached to the gear strut by a bracket, and moves with the gear strut. The outboard door is hinged to the wing and mated to the center door at the inboard edge. The outboard door is driven by an adjustable link attached to the gear strut forward brace.

F. Bogie Beams (See Figure 32-7)

(1) The main gear bogie beam assembly consists of a one piece tubular member that is hinged to the main gear strut piston by a pivot pin. The basic purpose for the bogie beam is to provide a platform for the four wheels and brakes on each main gear strut. The forward end of the bogie beam supports the forward axle and a clevis mounting for the bogie trim cylinder. The aft end of the beam supports the aft axle.

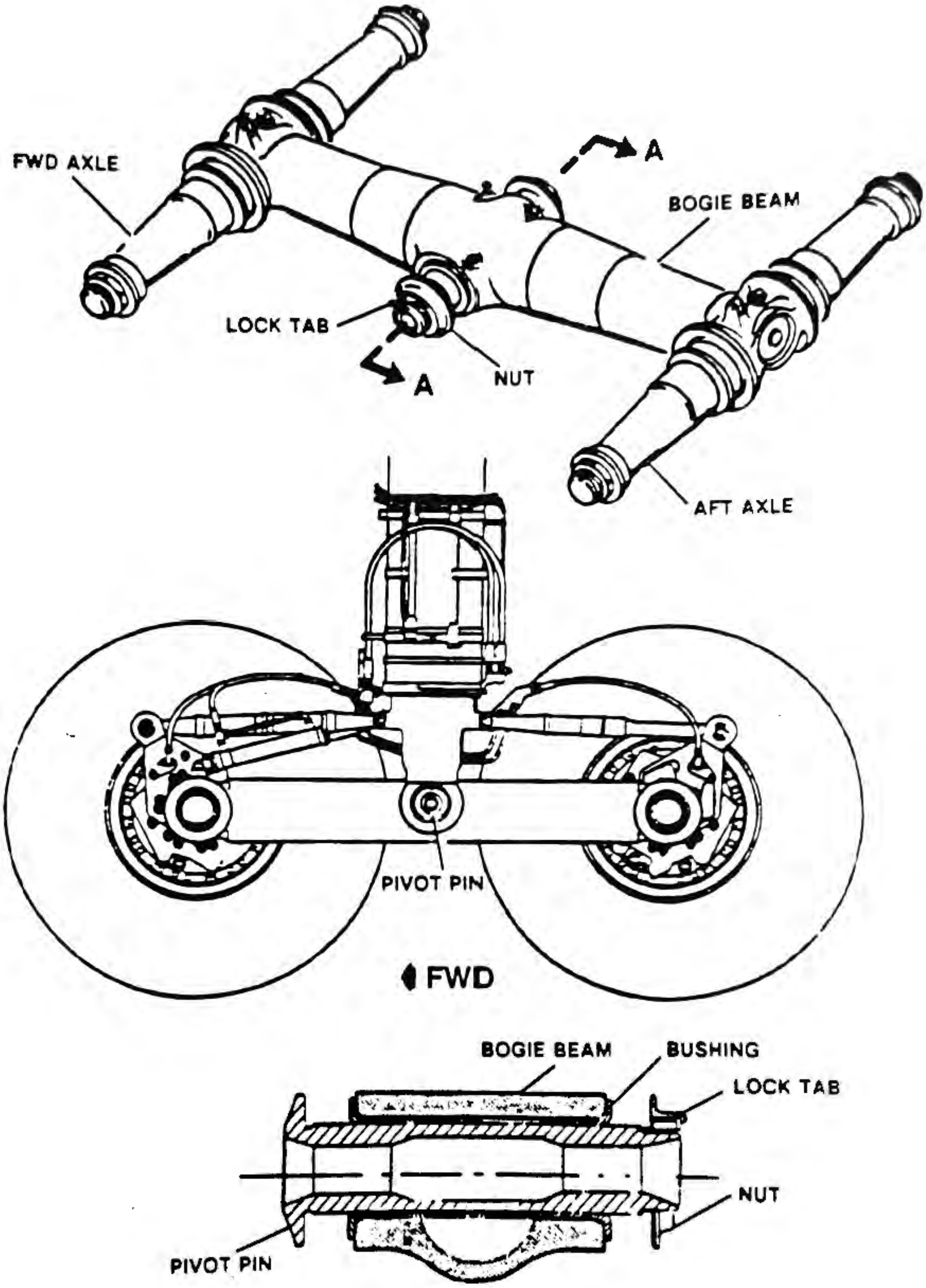
G. Operation

(1) When the main gear strut is in the static condition, the piston is extended 2 inches from the fully compressed position. The oil level is slightly above the top of the piston head, and the space above the oil level is charged with nitrogen. As the weight of the airplane lifts off the main gear, the fluid that is trapped in the chamber between the piston and the cylinder casing seats the floating valve and meters the fluid past the piston head. This dampens the action of the piston as it extends and prevents the piston from being damaged when it reaches the end of travel.



MAIN GEAR DOORS

Figure 32-6



SECTION A - A

MAIN GEAR BOGIE BEAM
Figure 32-7

FTX80107

(2) As the airplane settles on the main gear during landing, the strut compresses and fluid is metered past the piston head floating valve and the metering plate on the end of the perforated tube. As the piston compresses, the metering pin travels through the orifice of the metering plate and controls the flow of fluid through the orifice. The tapered metering pin closes the orifice as the strut compresses and slows the compression rate of the piston to prevent high-shock load during landing. Compression of the nitrogen in the top of the strut prevents the strut from bottoming in the cylinder.

(3) During retraction cycle, the main gear downlock bungee cylinders push the actuator levers of the downlock links, breaking the links overcenter. As the bungee cylinders extend, they fold the downlock links which break the side braces upward at the knee. The main gear actuating cylinder retracts and pulls the gear up into the wheel wells. As the gear retracts, the upper link of the side braces is folded up parallel to the torque tube with the downlock links. The swivel links fold back against the upper links. During the last few degrees of retraction cycle, the torque tube rotates until the side brace is on the aft side of it and the gear is latched.

(4) During the extension cycle, the uplatches release the gear and the main gear actuating cylinders push the gear out of the wheel wells. As the gear drops, the side braces rotate around the torque tube and unfold. The bungee cylinders and springs pull on the downlock levers unfolding the links. When the gear reaches the down position, the side braces are in a straight line and the downlock links are actuated overcenter to lock the gear down.

(5) The bogie beam has two basic functions. First, to provide a platform for the four wheels and brakes on each main gear strut. Second, to pivot on the end of the main gear piston and provide even distribution of airplane weight to all wheels, and to allow the wheels to follow the contour of the terrain over which the airplane is taxiied or towed.

3. Nose Gear and Doors - Description and Operation

A. General (See Figures 32-8 and 32-9)

(1) The nose gear is a dual-wheel, steerable oleo shock strut unit which provides a platform for the rolling gear, absorbs landing shock, retracts forward and upward into the fuselage during flight, and is completely enclosed by doors when retracted.

(2) The nose gear strut is supported by a crossarm, two side braces and the drag links. The wheels are mounted on the axle which is attached to the lower end of the strut piston by two high shear bolts. The downlock links, attached between the drag links and the crossarm, lock the drag links and gear in the down position.

(3) The shock strut piston and axle are connected to the strut cylinder by torque links, which serve to align the piston with the cylinder rotationally. When the gear is retracted, the nosewheel well is completely enclosed by four doors. The two forward doors are driven by linkages which are connected to the side braces. The aft doors are linked to the gear strut and move with the strut. The ground shift mechanism, driven by a linkage connected to the torque links, positions, the rudder pedal steering mechanism in operational condition when the nose gear strut is compressed.

B. Nose Gear Strut (See Figure 32-10)

(1) The nose gear shock strut consists of a cylinder, piston, and torque links. The cylinder supports the attach fittings for the lower drag link, side braces, and steering collar. The upper end of the cylinder is splined to mate with the crossarm. The air filler valve is installed in the top of the cylinder. The piston is installed inside the cylinder, and is the shock absorber and support for the axle and wheels. The torque links are attached to the cylinder collar and to the piston clevis and transmit steering motion from the steering collar to the piston and wheels.

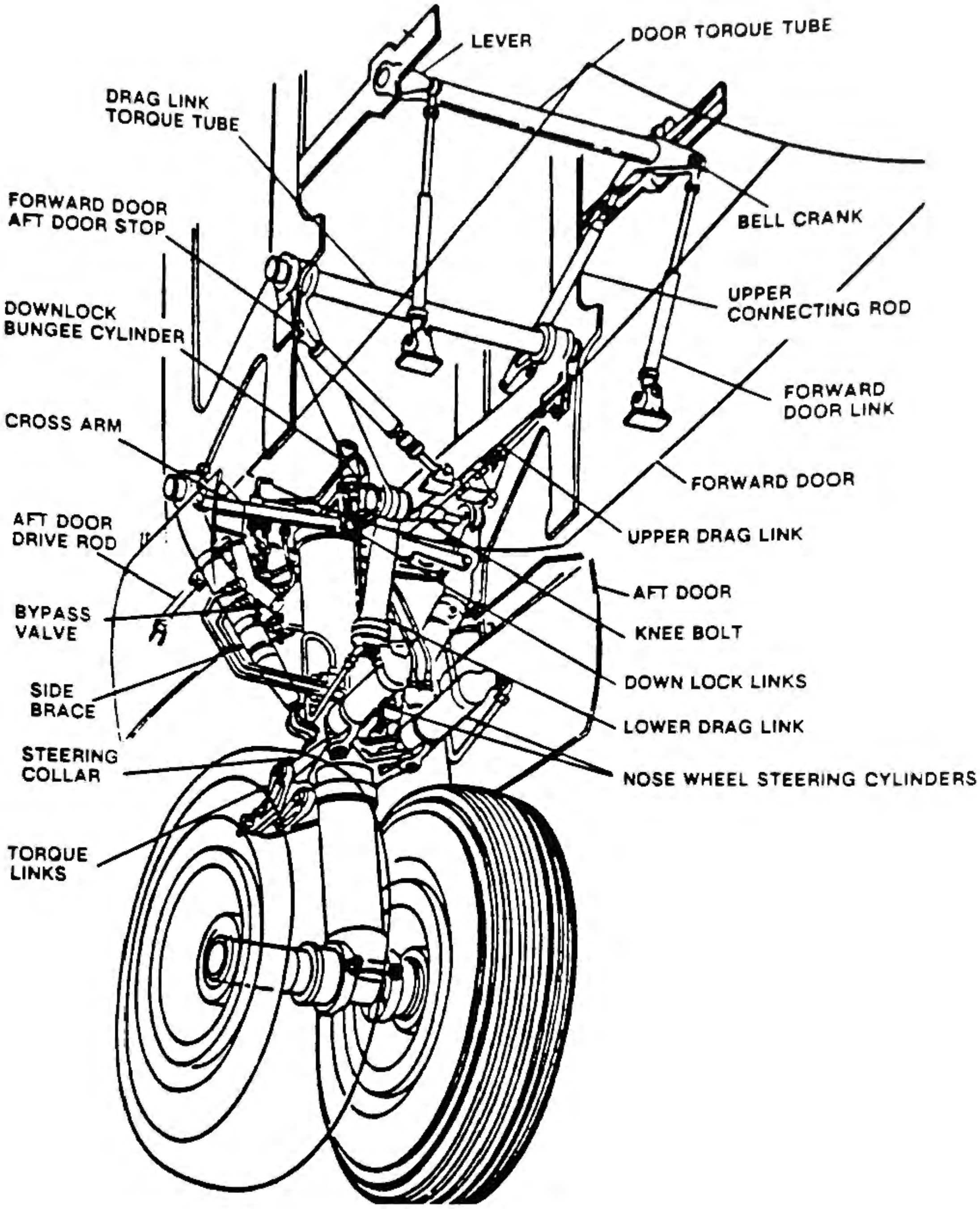
(2) Internally, the nose gear strut contains a metering device to dampen extension and compression rates, a centering device to align the piston fore and aft when extended, and seals to retain the oil and air pressure in the strut.

(3) A perforated tube assembly is installed in the cylinder and positions the metering plate, which also restricts fluid flow through the piston. The perforated tube is sealed to the piston by two compression rings. The centering cam follower is keyed to the cylinder, positioned by the piston bearing and adapter, and is retained by the gland nut.

C. Nose Gear Linkage

(1) The nose gear linkage consists of the side braces, drag links, and downlock links. The side braces and crossarm support the gear vertically and laterally. The lower ends of the side braces are tapered to an eye fitting which attaches to a clevis boss on the sides of the shock strut near the steering collar. The upper end of the each side brace has an integral journal which connects the brace to the support structure. The crossarm is attached to the side braces. The left side brace has an extension which is the aft attach point for the nose gear actuating cylinder. The aft door drive rods also attach to the side braces.

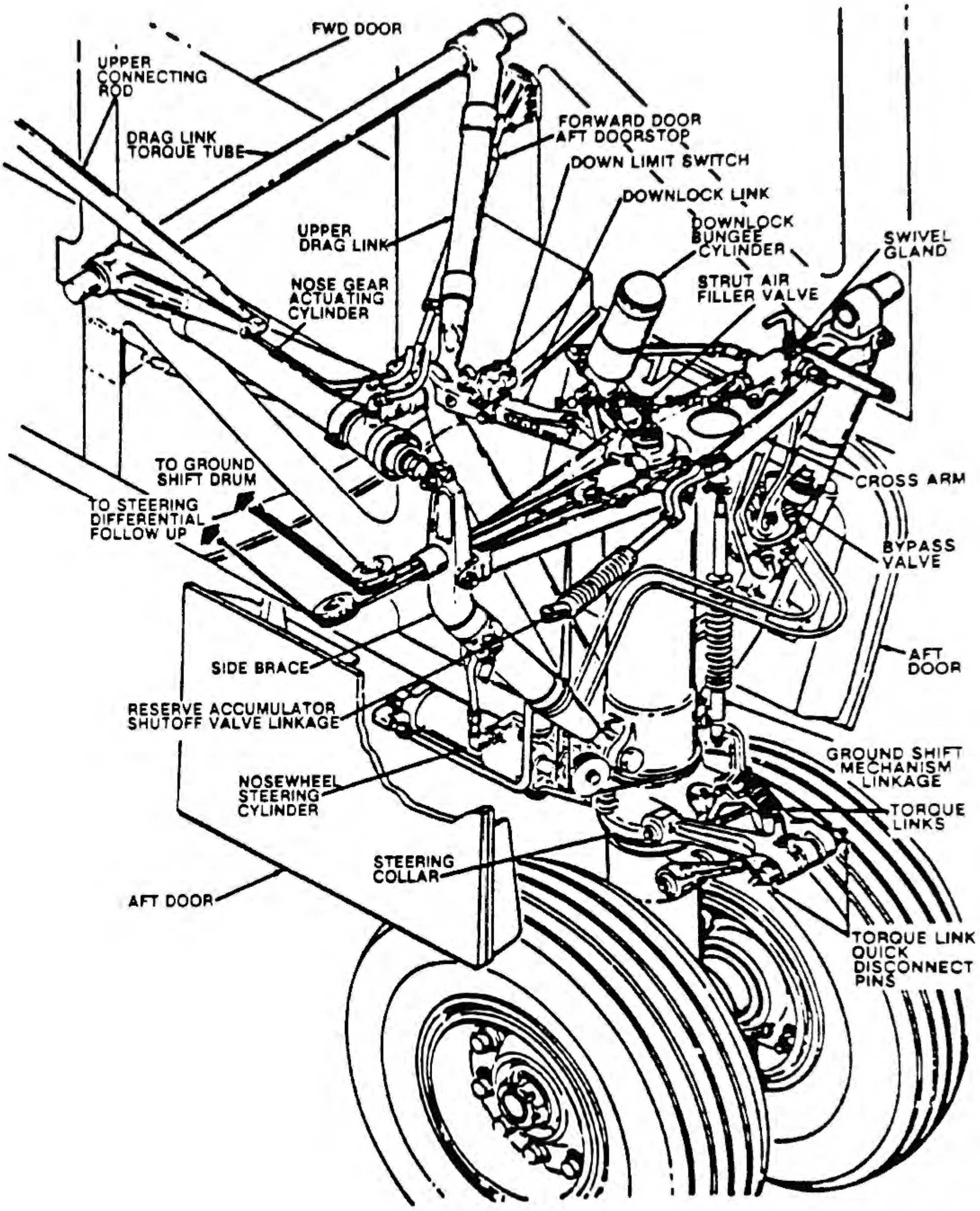
(2) The drag links attach to the torque tube at the top and to a clevis on the shock strut above the steering collar, and support the shock strut longitudinally. The gear is locked in the down position by the downlock links, which attach to the drag links and to the crossarm.



NOSE GEAR -- FORWARD SIDE

Figure 32-8

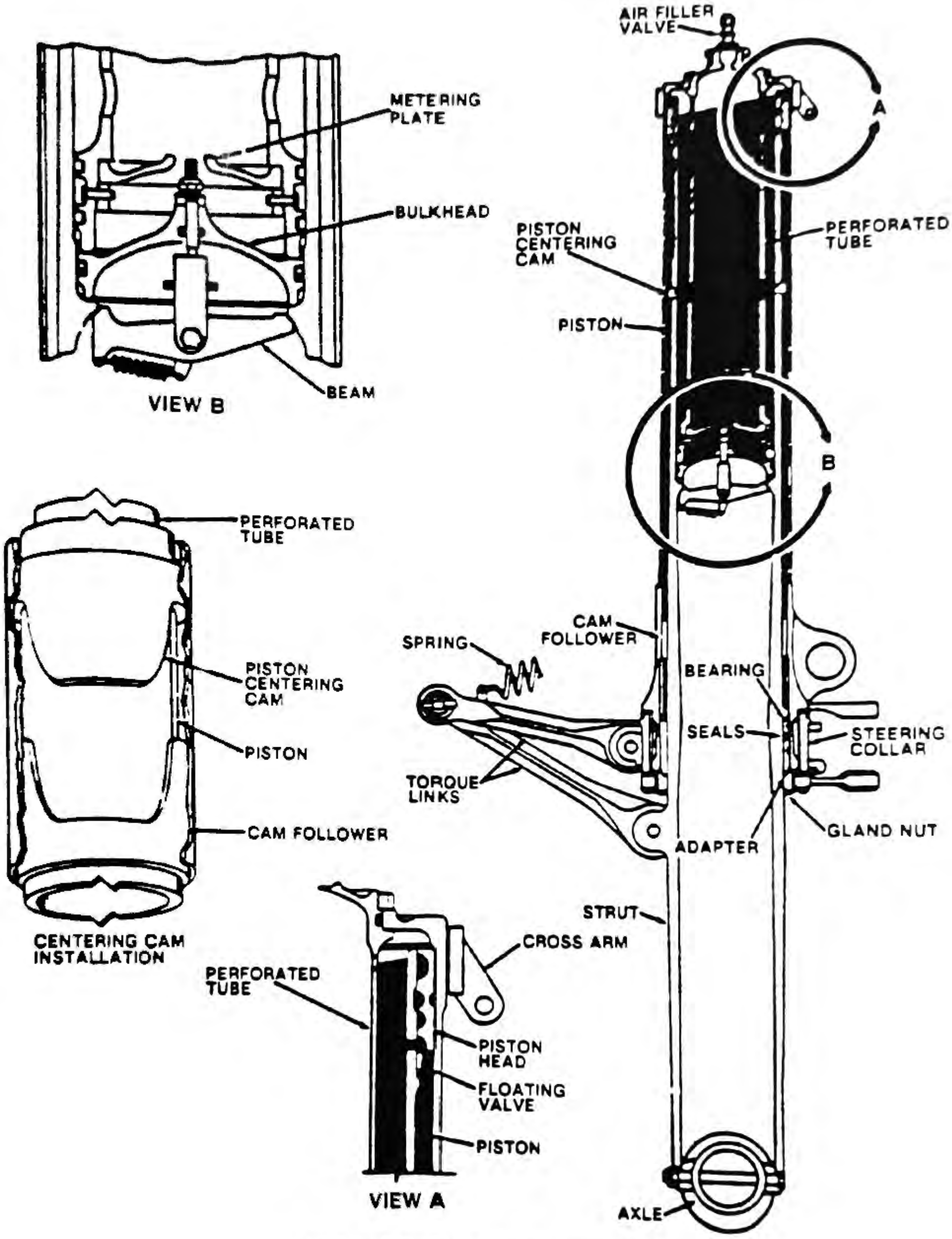
FTX80108



NOSE GEAR - AFT SIDE

FTX80109

Figure 32-9



NOSE GEAR STRUT CUTAWAY

FTX80110

Figure 32-10

D. Nose Gear Torque Links

(1) The nose gear torque links are two steel, A-frame type members used to connect the shock strut cylinder to the piston and wheel assembly. They serve to restrict piston extension length during gear retraction and transmit steering motion from the steering collar to the piston and wheels. The upper and lower links are connected by a quick-disconnect bolt. A bracket is attached to the upper link and forms a connection point for the ground shift mechanism actuator.

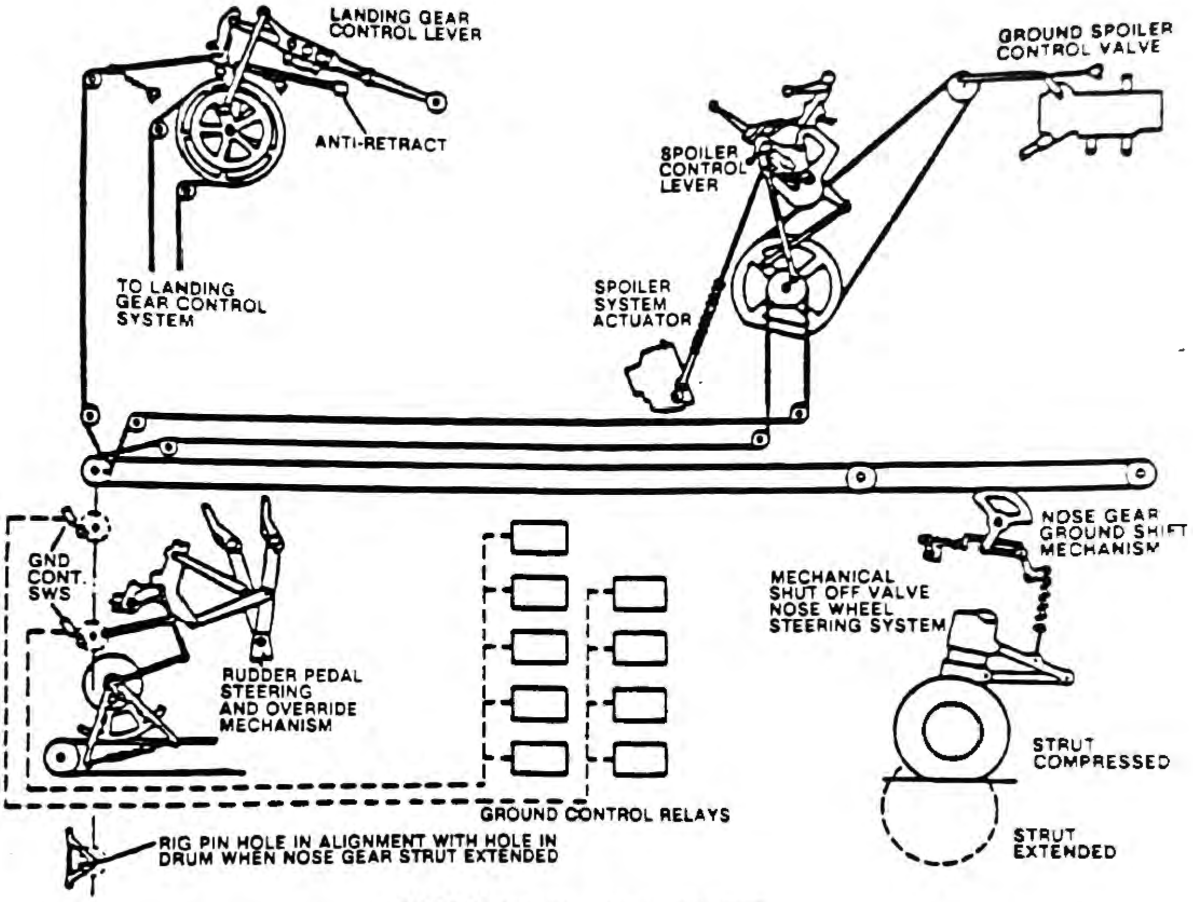
E. Nose Gear Doors and Linkage

(1) The nose gear doors enclose the wheel well and form the contour of the lower fuselage nose section. They consist of four individual sections; two forward doors, and two aft doors. The two forward doors open and close during gear travel; the two aft doors move with the strut at all times. The forward doors are driven by linkages connected to the left side brace extension. The aft doors are driven by links connected to the side braces. The forward door links are telescoping tubes which contain latch mechanisms which are cam actuated by a release trigger, which is used to open the doors manually for ground maintenance access.

F. Nose Gear Ground Shift Mechanism (See Figures 32-11 & 32-12)

(1) The nose gear ground shift mechanism is a mechanically actuated device used to actuate the ground shift drum, located on the pedal steering override mechanism bracket below the rudder pedals. The ground shift drum actuates the rudder pedal steering shift, spoiler automatic extension linkage, the landing gear control lever antiretraction latch, and the oleo switches which actuate the ground control relays.

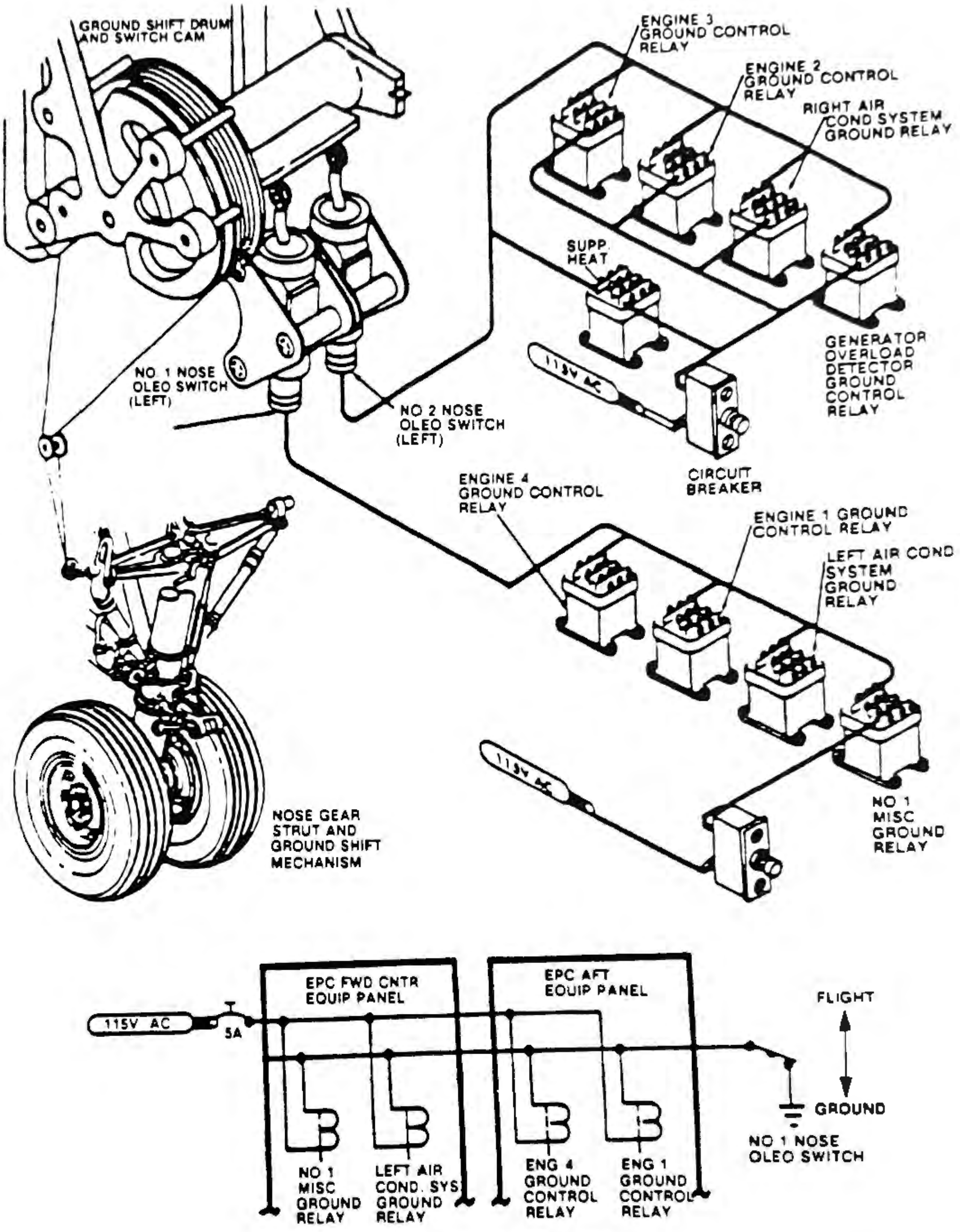
(2) The ground shift mechanism is located on the left crossarm, and the drive linkage runs parallel to the strut and attaches to the nose gear torque links. A two-way, closed cable system runs between the drive linkage on the nose gear strut and the pedal steering override assembly in the flight compartment.


LANDING GEAR CONTROL LEVER
GROUND SPOILER CONTROL VALVE
ANTI-RETRACT
SPOILER CONTROL LEVER
TO LANDING GEAR CONTROL SYSTEM
SPOILER SYSTEM ACTUATOR
GND CONT. SWS
NOSE GEAR GROUND SHIFT MECHANISM
MECHANICAL SHUT OFF VALVE NOSE WHEEL STEERING SYSTEM
RUDDER PEDAL STEERING AND OVERRIDE MECHANISM
STRUT COMPRESSED
GROUND CONTROL RELAYS
STRUT EXTENDED
RIG PIN HOLE IN ALIGNMENT WITH HOLE IN DRUM WHEN NOSE GEAR STRUT EXTENDED

GROUND SHIFT SCHEMATIC

FTX80112

Figure 32-11


GROUND SHIFT DRUM AND SWITCH CAM
ENGINE 3 GROUND CONTROL RELAY
ENGINE 2 GROUND CONTROL RELAY
RIGHT AIR COND SYSTEM GROUND RELAY
SUPP. HEAT
GENERATOR OVERLOAD DETECTOR GROUND CONTROL RELAY
115V AC
CIRCUIT BREAKER
NO. 1 NOSE OLEO SWITCH (LEFT)
NO 2 NOSE OLEO SWITCH (LEFT)
ENGINE 4 GROUND CONTROL RELAY
ENGINE 1 GROUND CONTROL RELAY
LEFT AIR COND SYSTEM GROUND RELAY
115V AC
NO 1 MISC GROUND RELAY
NOSE GEAR STRUT AND GROUND SHIFT MECHANISM
EPC FWD CNTR EQUIP PANEL
EPC AFT EQUIP PANEL
115V AC
5A
FLIGHT
GROUND
NO 1 NOSE OLEO SWITCH
NO 1 MISC GROUND RELAY
LEFT AIR COND. SYS GROUND RELAY
ENG 4 GROUND CONTROL RELAY
ENG 1 GROUND CONTROL RELAY

GROUND CONTROL RELAY SYSTEM

FTX80113

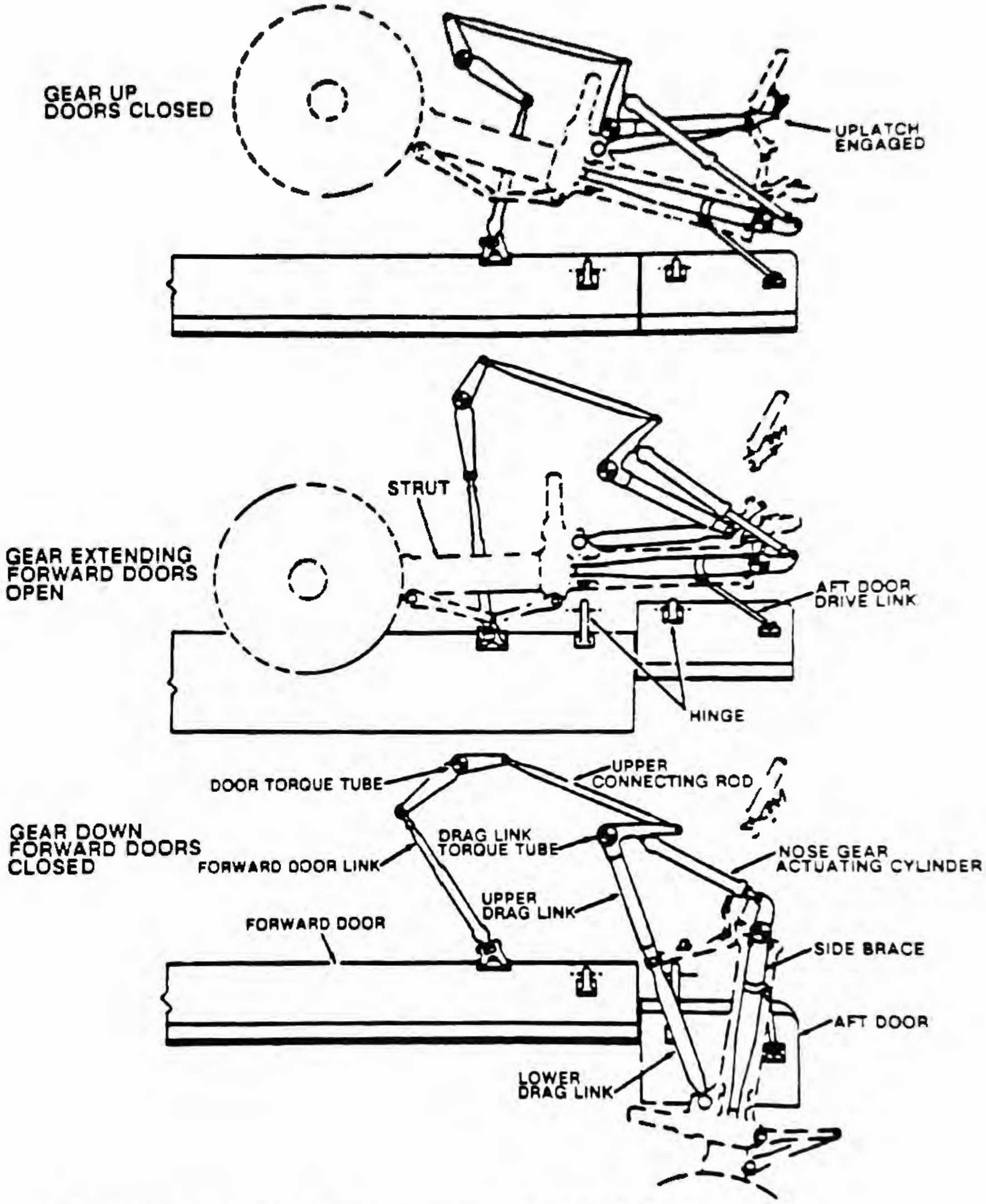
Figure 32-12

G. Operation (See Figure 32-13)

(1) The nose gear strut is driven through the gear retract and extend cycles by the nose gear actuating cylinder. The overcenter linkage is unlocked hydraulically by the bungee cylinder, and is locked mechanically by the springs in the bungee cylinder.

(2) The forward nose gear doors are sequenced to the open position during the first few degrees of gear travel and are closed during the last few degrees of gear travel in both the extension and retraction cycles. The aft doors are linked directly to the side braces and travel with the gear.

(3) The ground shift mechanism is actuated by the nose gear torque links. When the nose gear strut is extended, the upper torque link draws the linkage downward, rotating the cable drum and positioning the pedal steering override mechanism in flight mode. When in flight mode, the pedal steering mechanism is locked out, the antiretraction cables are pulled to the release position, and the ground control relay oleo switches are actuated. When the nose gear strut is compressed, the procedure is reversed: the pedal steering mechanism is engaged, the antiretraction latch is engaged, and the nose gear oleo switches are positioned in ground mode.



NOSE GEAR DOORS AND LINKAGE - OPERATIONAL

FTX80111

Figure 32-13

4. Extension and Retraction - Description and Operation

A. General (See Figures 32-14 & 32-15, 32-16)

(1) Landing gear extension and retraction is accomplished by actuation of the mechanical control system and the hydraulic control system.

(2) The landing gear is actuated by two hydraulic systems, one for the nose gear and the other for the main gear. The nose gear system consists of a control valve, an actuating cylinder, a downlock bungee cylinder, and an uplatch cylinder. The main gear system consists of a control valve, two gear actuating cylinders, bungee cylinders, uplatch cylinders, door actuating cylinders and control valves, door uplatch cylinders, and a door manual open valve.

(3) The two hydraulic control systems are controlled from the flight compartment by a mechanical control system, which consists of two levers bussed to actuate as a single lever, the antiretraction latch, and the nose and main gear uplatch mechanism, the main gear door uplatch mechanism, and the door followup mechanism.

B. Operation

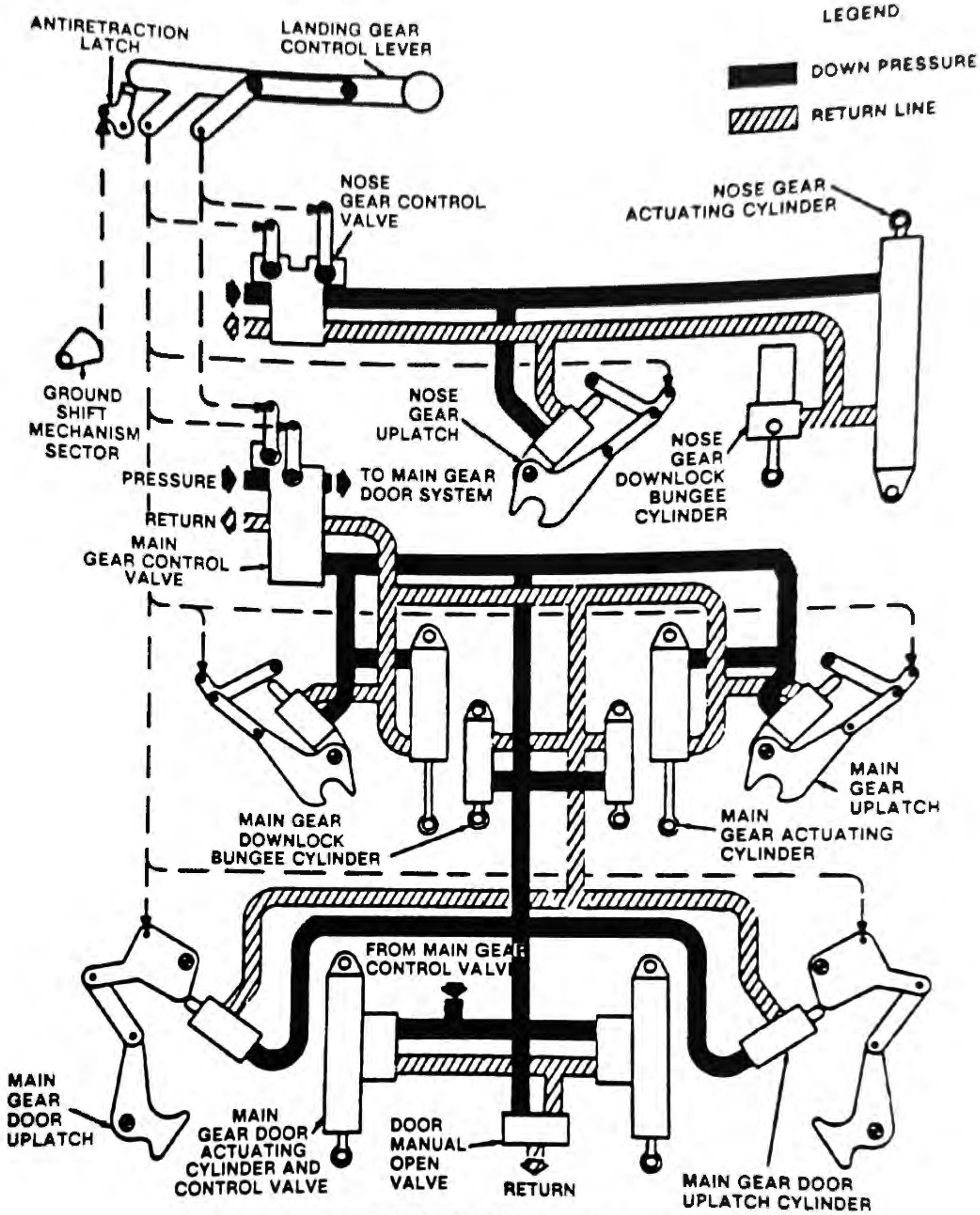
(1) When the landing gear control lever is placed in the gear up position, the mechanical control system positions the nose gear and main gear control valves to port hydraulic pressure to the main and nose gear downlock bungee cylinders and actuating cylinders. The bungee cylinders unlock the downlock linkages, and the actuating cylinders retract the gear. When the gear reach the up position, the uplatches hold the gear in the retracted position.

(2) During the first few degrees of gear travel, the main gear door followup mechanism positions the door control valves to the open position and the main gear inboard doors open. When the gear is within the last few degrees of travel, the door valves are positioned to the closed position and the inboard doors close. The doors are engaged in the uplatches when fully closed.

(3) After the gear is up and latched, the landing gear control lever may be moved to the uplatch check position to verify latch engagement. This allows the gear to rest on the latches. After the uplatch check is made, the landing gear control lever is placed in the gear up position to hydraulically hold the gear weight off the uplatches.

(4) To extend the gear, the landing gear control lever is moved to the gear down position. The mechanical control system positions the nose and main gear control valves to port hydraulic pressure to the downlines of each system as follows: The nose gear control valve ports pressure to the uplatch cylinder, disengaging the uplatch mechanism, and to the gear actuating cylinder to extend the gear. When the gear is fully extended, the downlock bungee cylinder locks the downlock links overcenter. Simultaneously, the main gear control valve ports hydraulic pressure to both main gear uplatch cylinders and door uplatch cylinders, actuating the latch mechanisms and releasing the doors and gear. Pressure to the main gear actuating cylinders passes through restrictors to slow the gear actuation. The main gear inboard door followup mechanism opens the doors within the first few degrees of gear travel and close the doors within the last few degrees of gear travel. The downlock bungee cylinders and bungee springs actuate the downlock links to the overcenter position.

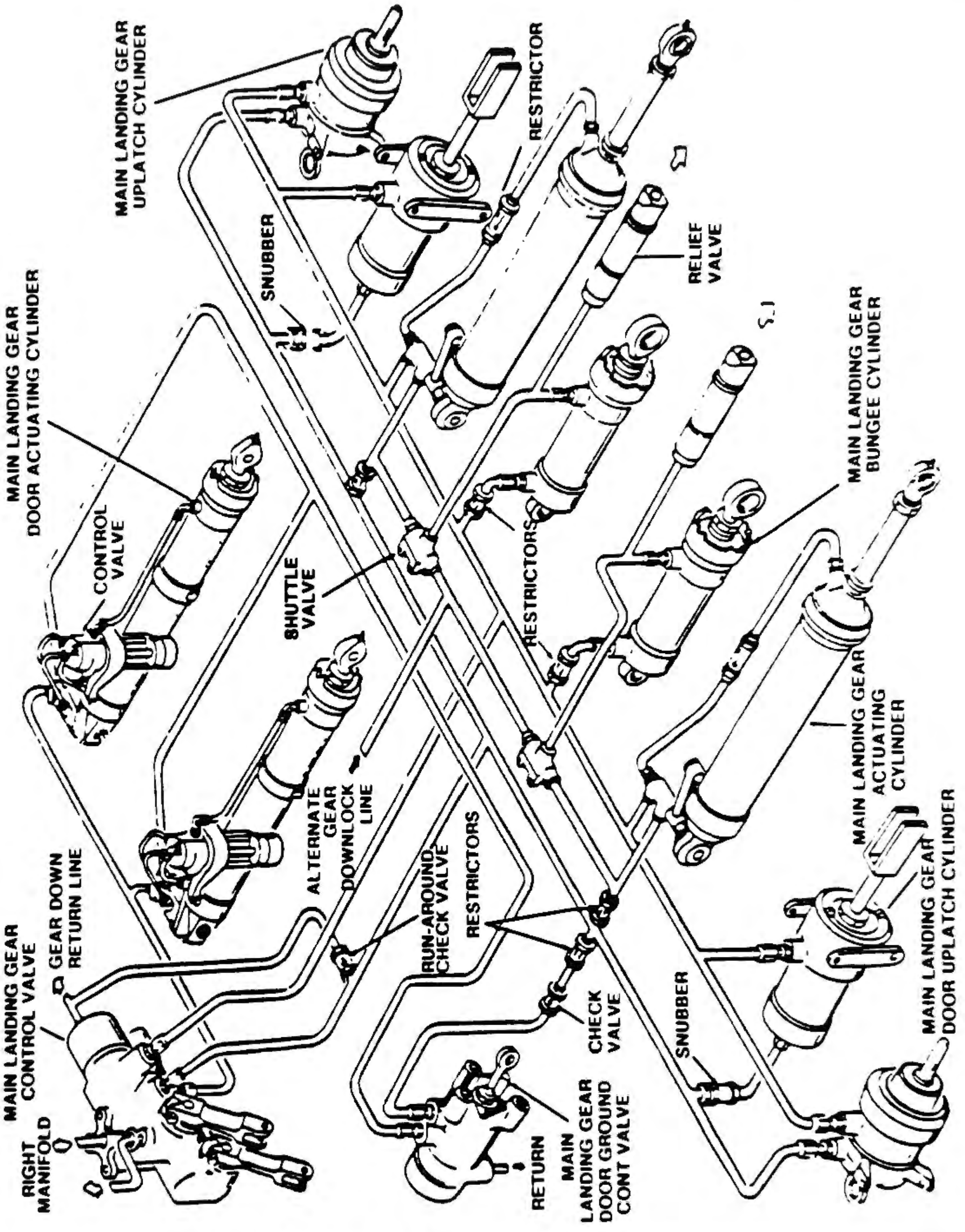
(5) In case of a hydraulic power failure or a jammed control valve, the gear can be extended by free-fall and the uplatches released mechanically by splitting the bussed landing gear control levers and placing the long lever in gear down position.


LEGEND
■ DOWN PRESSURE
▨ RETURN LINE
ANTIRETRACTION LATCH
LANDING GEAR CONTROL LEVER
NOSE GEAR CONTROL VALVE
NOSE GEAR ACTUATING CYLINDER
GROUND SHIFT MECHANISM SECTOR
NOSE GEAR UPLATCH
NOSE GEAR DOWNLOCK BUNGEE CYLINDER
PRESSURE
TO MAIN GEAR DOOR SYSTEM
RETURN
MAIN GEAR CONTROL VALVE
MAIN GEAR UPLATCH
MAIN GEAR DOWNLOCK BUNGEE CYLINDER
MAIN GEAR ACTUATING CYLINDER
FROM MAIN GEAR CONTROL VALVE
MAIN GEAR DOOR UPLATCH
MAIN GEAR DOOR ACTUATING CYLINDER AND CONTROL VALVE
DOOR MANUAL OPEN VALVE
RETURN
MAIN GEAR DOOR UPLATCH CYLINDER

LANDING GEAR EXTENSION AND RETRACTION SIMPLIFIED SCHEMATIC

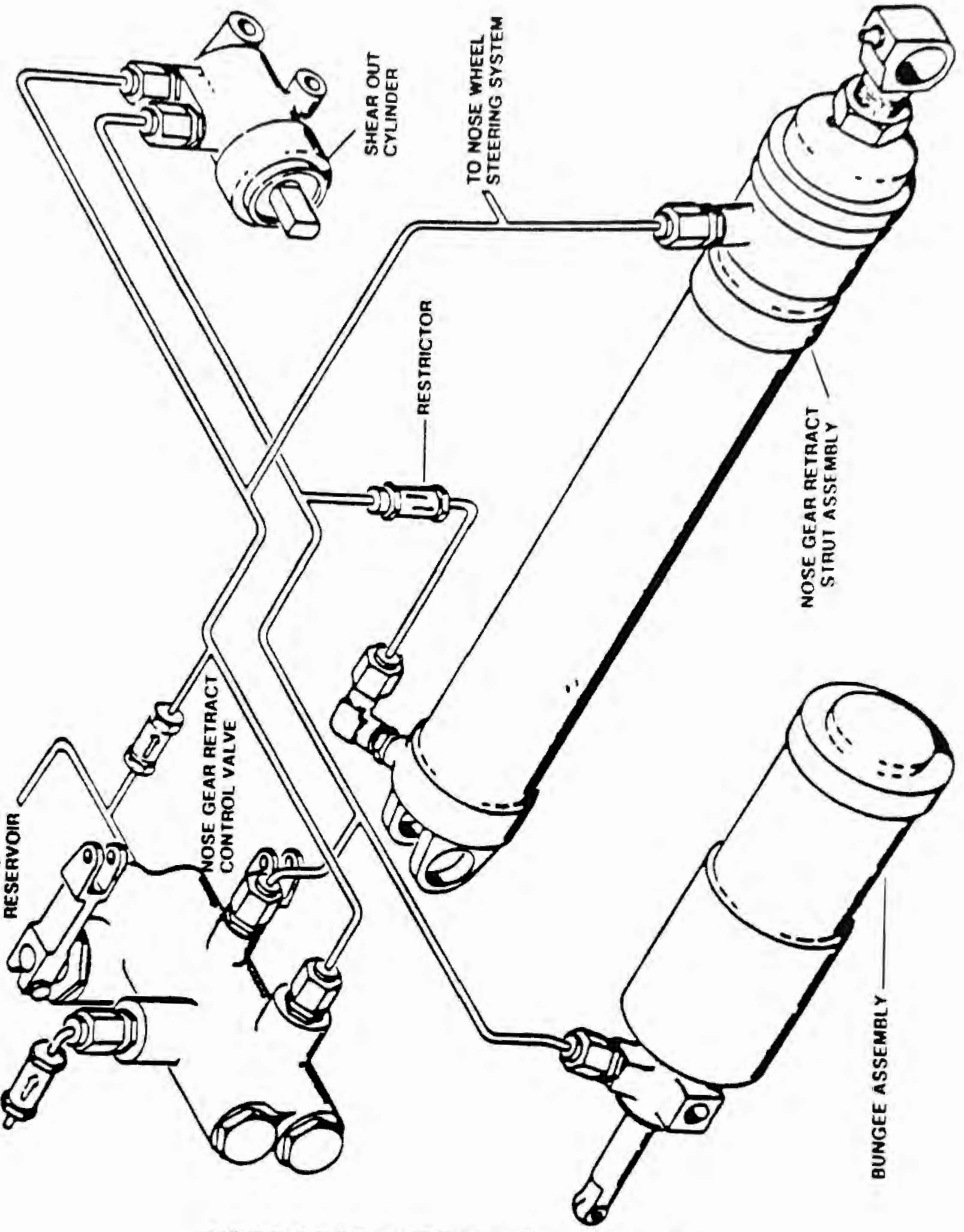
FTX80114

Figure 32-14


MAIN LANDING GEAR UPLATCH CYLINDER
RESTRICTOR
MAIN LANDING GEAR DOOR ACTUATING CYLINDER
CONTROL VALVE
SNUBBER
RELIEF VALVE
SHUTTLE VALVE
RESTRICTORS
MAIN LANDING GEAR BUNGEE CYLINDER
MAIN LANDING GEAR ACTUATING CYLINDER
ALTERNATE GEAR DOWNLOCK LINE
MAIN LANDING GEAR DOOR UPLATCH CYLINDER
MAIN LANDING GEAR CONTROL VALVE
GEAR DOWN RETURN LINE
RUN-AROUND CHECK VALVE
RESTRICTORS
SNUBBER
CHECK VALVE
RIGHT MANIFOLD
RETURN
MAIN LANDING GEAR DOOR GROUND CONT VALVE

LANDING GEAR HYDRAULIC SCHEMATIC
Figure 32-15

FTX80115


SHEAR OUT CYLINDER
TO NOSE WHEEL STEERING SYSTEM
RESTRICTOR
NOSE GEAR RETRACT STRUT ASSEMBLY
TO RESERVOIR
NOSE GEAR RETRACT CONTROL VALVE
BUNGEE ASSEMBLY
FTX80141

NOSE GEAR HYDRAULIC SCHEMATIC
Figure 32-16

5. Landing Gear Mechanical Control System - Description and Operation

A. General (See Figure 32-17)

(1) The landing gear mechanical control system provides a means for positioning the landing gear control valves to retract and extend the gear hydraulically. It also provides a mechanical means for releasing the gear and doors to permit a free-fall gear extension.

(2) The mechanical control system consists of four sets of cables which are actuated by a bussed control lever, an antiretraction latch and cable, the nose and main gear uplatch mechanisms, main gear door uplatch mechanisms, and the nose and main gear safety couplings. The main gear door followup cables and mechanism, although not directly connected, are a part of this system.

(3) The landing gear control lever is used to position the nose and main gear dual-spool control valves. The short lever actuates the control valve slide of the two control valves. The long lever actuates the bypass slide of the two control valves and the mechanical uplatch release cables.

(4) The antiretraction latch is a spring-loaded device which physically blocks the landing gear control lever from being moved to the up detent position when the airplane is on the ground. The latch can be manually overridden.

(5) The nose gear, main gear, and main gear door uplatch mechanisms are mechanical overcenter latches used to hold the gear and doors in the retracted position. Two methods of releasing the latches are utilized. The normal method is accomplished by use of hydraulic cylinders, and the second method is by use of a cable system which is actuated by the long lever of the landing gear control lever.

(6) The main gear door followup mechanisms are mechanical and cable systems used to sequence the opening and closing of the main gear inboard doors during main gear travel cycles. The mechanism is actuated by the main gear torque tube assembly.

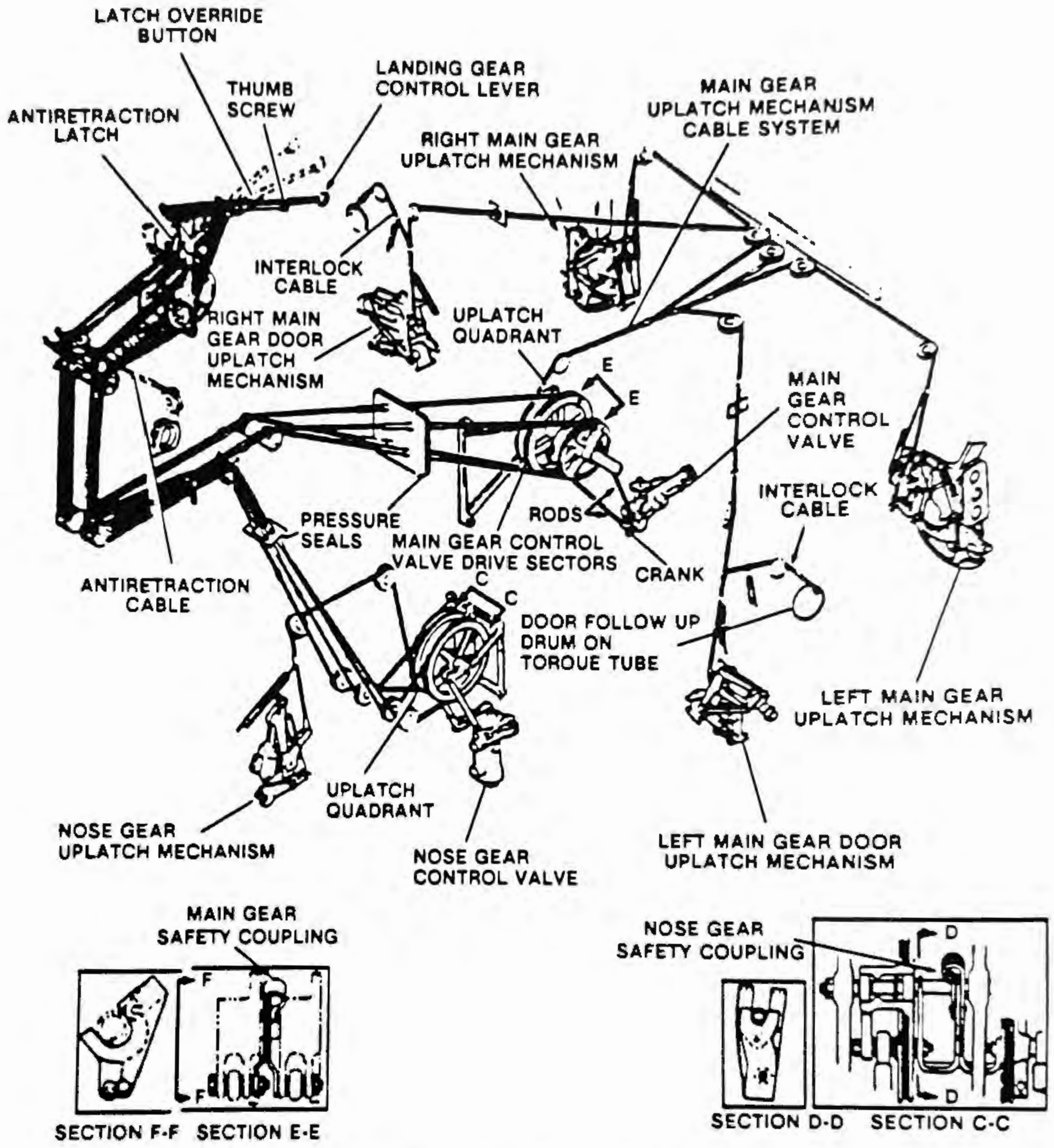
(7) The landing gear safety couplings are installed between the two cable drive sectors for the nose gear and main gear hydraulic control valves. They serve to prevent inadvertent operation of the landing gear control valves in the event of a cable failure.

B. Landing Gear Control Lever and Antiretraction Latch (See Figure 32-18)

(1) The landing gear control lever is a bussed lever which is used to position the main and nose gear control valves. The antiretraction latch is a spring-loaded device which prevents inadvertent retraction of the landing gear when the weight of the airplane is on the nose gear strut. The latch can be manually disengaged to move the lever intentionally out of the down detent position.

(2) The landing gear control lever assembly consists of a long lever and a short lever bussed with a knurled screw. The long lever is used to actuate the bypass slide of the landing gear control valves and to release the uplatches mechanically. The short lever is used to actuate the control slide of the control valves. The knurled screw may be removed to operate the long lever independently in the event of a jammed control valve.

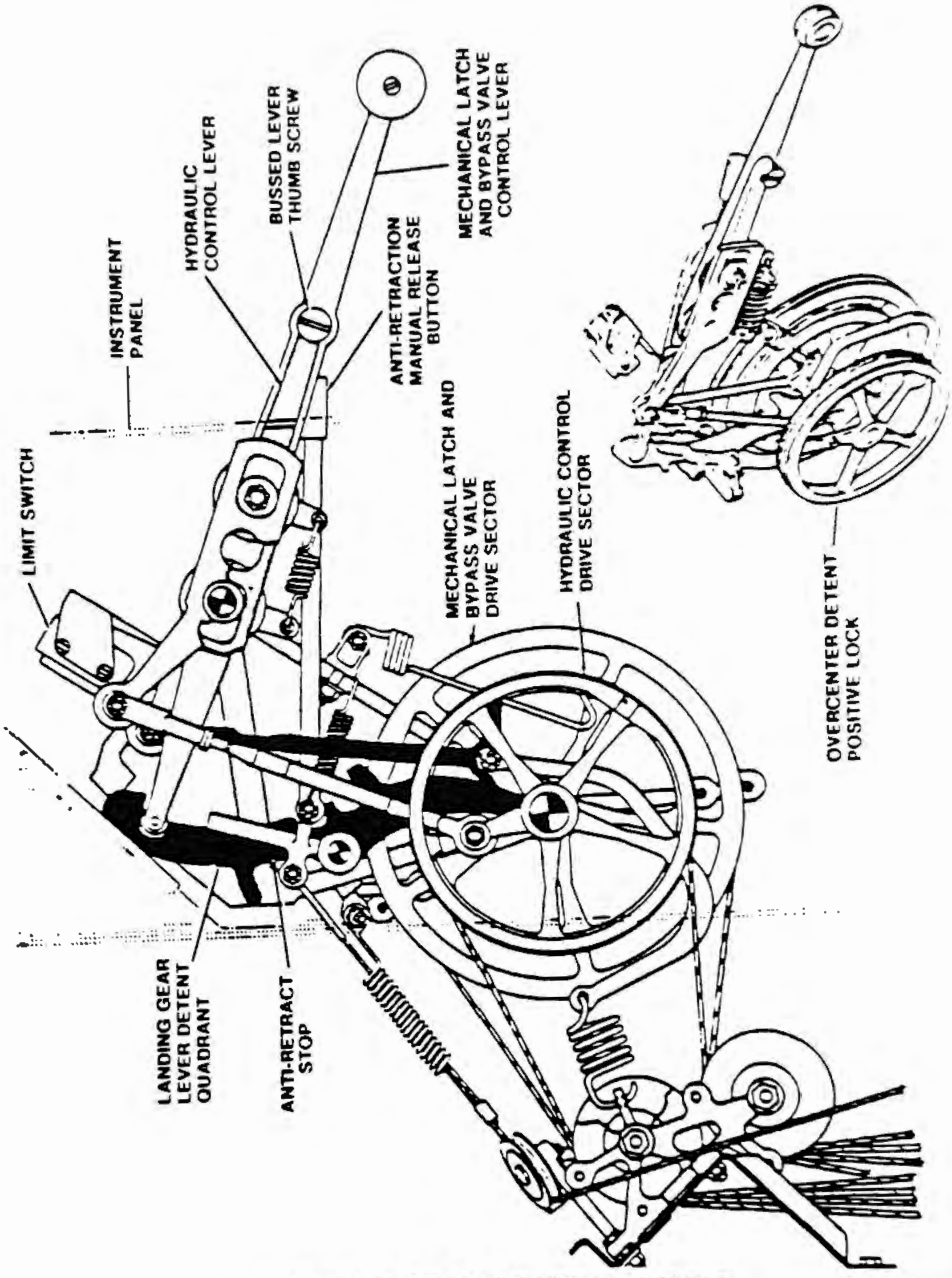
(3) The antiretraction latch assembly consists of a latch, a stop fitting, release button, and a cable which connects the assembly to the ground shift mechanism. When the nose gear strut is compressed, the ground shift cable pulls the latch into position to block the landing gear control lever and prevent inadvertent operation of the gear retraction system. The manual release button may be used to override the blocking latch and permit the control lever to be placed in gear up position.


LATCH OVERRIDE BUTTON
ANTIRETRACTION LATCH
THUMB SCREW
LANDING GEAR CONTROL LEVER
RIGHT MAIN GEAR UPLATCH MECHANISM
MAIN GEAR UPLATCH MECHANISM CABLE SYSTEM
INTERLOCK CABLE
RIGHT MAIN GEAR DOOR UPLATCH MECHANISM
UPLATCH QUADRANT
E
E
MAIN GEAR CONTROL VALVE
INTERLOCK CABLE
PRESSURE SEALS
RODS
MAIN GEAR CONTROL VALVE DRIVE SECTORS
CRANK
C
C
ANTIRETRACTION CABLE
DOOR FOLLOW UP DRUM ON TORQUE TUBE
LEFT MAIN GEAR UPLATCH MECHANISM
UPLATCH QUADRANT
NOSE GEAR UPLATCH MECHANISM
NOSE GEAR CONTROL VALVE
LEFT MAIN GEAR DOOR UPLATCH MECHANISM
MAIN GEAR SAFETY COUPLING
F
F
NOSE GEAR SAFETY COUPLING
D
D
SECTION F-F
SECTION E-E
SECTION D-D
SECTION C-C

LANDING GEAR MECHANICAL CONTROL SYSTEM -- SCHEMATIC

FTX80116

Figure 32-17


LIMIT SWITCH
INSTRUMENT PANEL
HYDRAULIC CONTROL LEVER
BUSSED LEVER THUMB SCREW
ANTI-RETRACTION MANUAL RELEASE BUTTON
MECHANICAL LATCH AND BYPASS VALVE CONTROL LEVER
MECHANICAL LATCH AND BYPASS VALVE DRIVE SECTOR
HYDRAULIC CONTROL DRIVE SECTOR
OVERCENTER DETENT POSITIVE LOCK
LANDING GEAR LEVER DETENT QUADRANT
ANTI-RETRACT STOP

LANDING GEAR CONTROL LEVER
Figure 32-18

FTX80117

C. Main Gear Uplatch Mechanisms (See Figure 32-19)

(1) The main gear uplatch mechanisms are mechanical means to hold the main gear in the retracted position. They are mechanically actuated to the latched position and hydraulically and/or mechanically actuated to the unlatched position. The mechanism consists of a support bracket, hook, hydraulic cylinder, and overcenter linkage.

(2) When the main gear is in the uplatch position, the overcenter links are in the extended position and the hook is pivoted around the uplatch roller. The roller is mounted at the base of the upper torque link of each main gear strut. The links are locked and held overcenter by spring tension. The more weight the gear applies to the hook, the tighter the links are locked.

(3) To extend the gear, hydraulic pressure is applied to the uplatch cylinder, which pushes the upper link to unlock the links from overcenter position. The uplatch cylinder and the weight of the gear on the hook continue to hold the links until the uplatch roller disengages from the hook and gear extends.

D. Main Gear Door Uplatch Mechanisms (See Figure 32-20)

(1) The main gear door uplatch mechanisms are mechanical means of holding the doors in the closed position. If the main gear uplatch should fail, the uplatch mechanism will hold the weight of the main gear. The uplatches are mechanically actuated to the latched position and unlatched hydraulically and/or mechanically. The uplatch mechanism consists of a support bracket, hook, hydraulic cylinder, overcenter links, and a spring-loaded roller on the door.

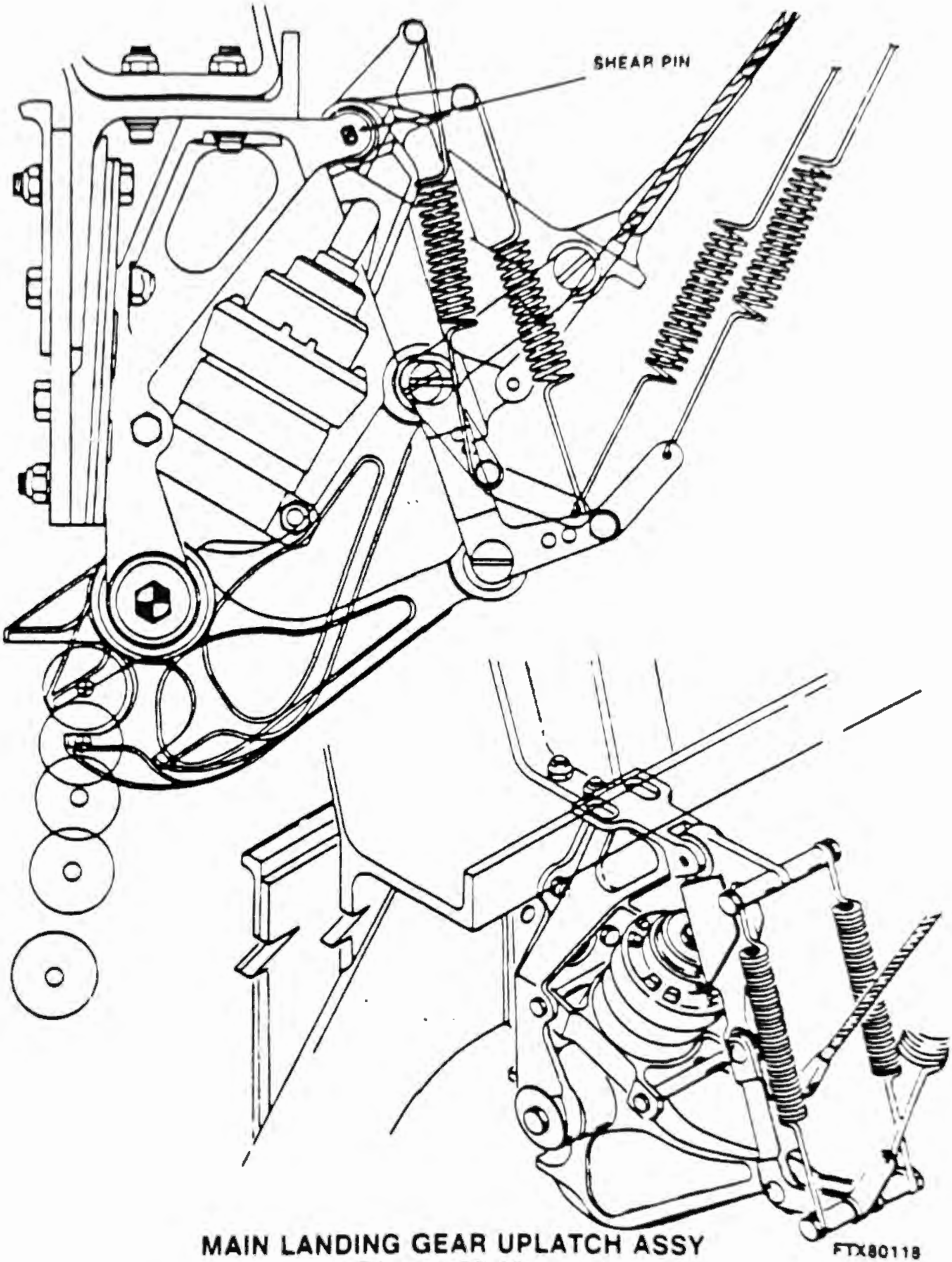
(2) When the main gear is in the down and locked position, hydraulic pressure holds the piston of the uplatch cylinder extended. This holds the link folded and the hook in the unlatched position. The spring-loaded roller is retained in the notch in the detent.

(3) When the landing gear control lever is placed in gear up position, hydraulic pressure pushes the door open, disengaging the roller from the detent and also retracting the uplatch cylinder piston. This allows the overcenter return springs to unfold and position the hook in the latch position. As the gear retracts, the door opens; when the gear is clear of the door, the door closes. As the door closes, the spring-loaded

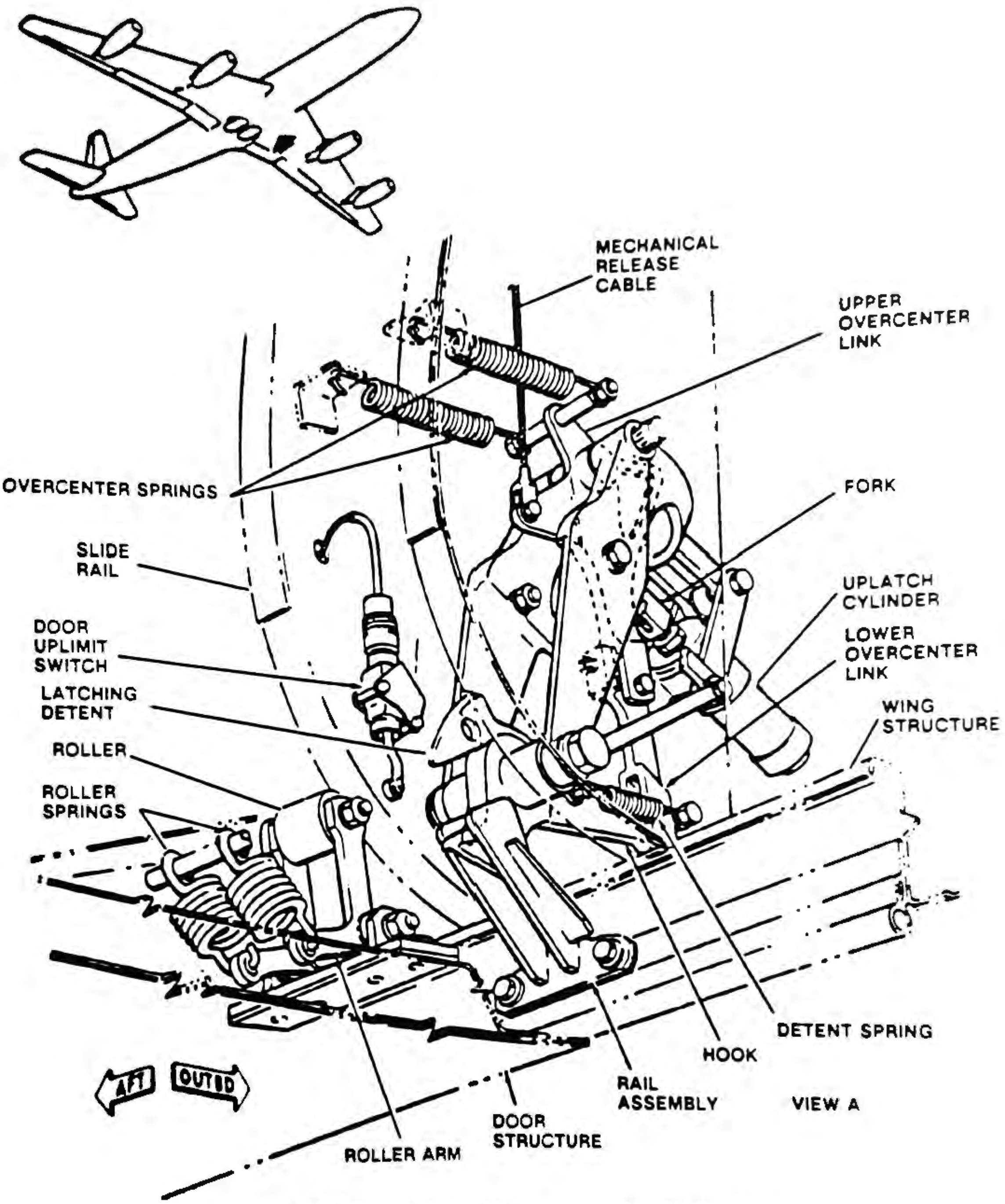
roller strikes the latching cam of the hook and rides the cam until it drops over the peak into the notch. The door is then closed and latched.

(4) When the main gear extends, hydraulic pressure extends the uplatch piston rod agains the unlatch link rollers, unlocking the links from overcenter and folding them. This rotates the hook to the unlatch position. As the hook rotates, the detent is pivoted clear of the spring-loaded roller. When the spring-loaded roller is clear of the hook, the detent is repositioned by the detent springs. When the gear is clear of the door, the door closes. The spring-loaded roller strikes the latching cam of the detent and rides it up over the peak into the catch. This holds the door closed when no hydraulic pressure is on the airplane.

(5) If a hydraulic system failure should occur, the uplatch can be released by the cable attached to the cable lever of the upper link. Tension on the cable unlocks the links from overcenter and folds them to the unlatch position. This allows the weight of the gear to push the door clear of the latches and to extend. The cable is actuated by the long lever of the landing gear control lever.



MAIN LANDING GEAR UPLATCH ASSY
Figure 32-19



MAIN GEAR DOOR UPLATCH MECHANISM FTX80119

Figure 32-20

E. Main Gear Door Followup Mechanism (See Figures 32-21 & 32-22)

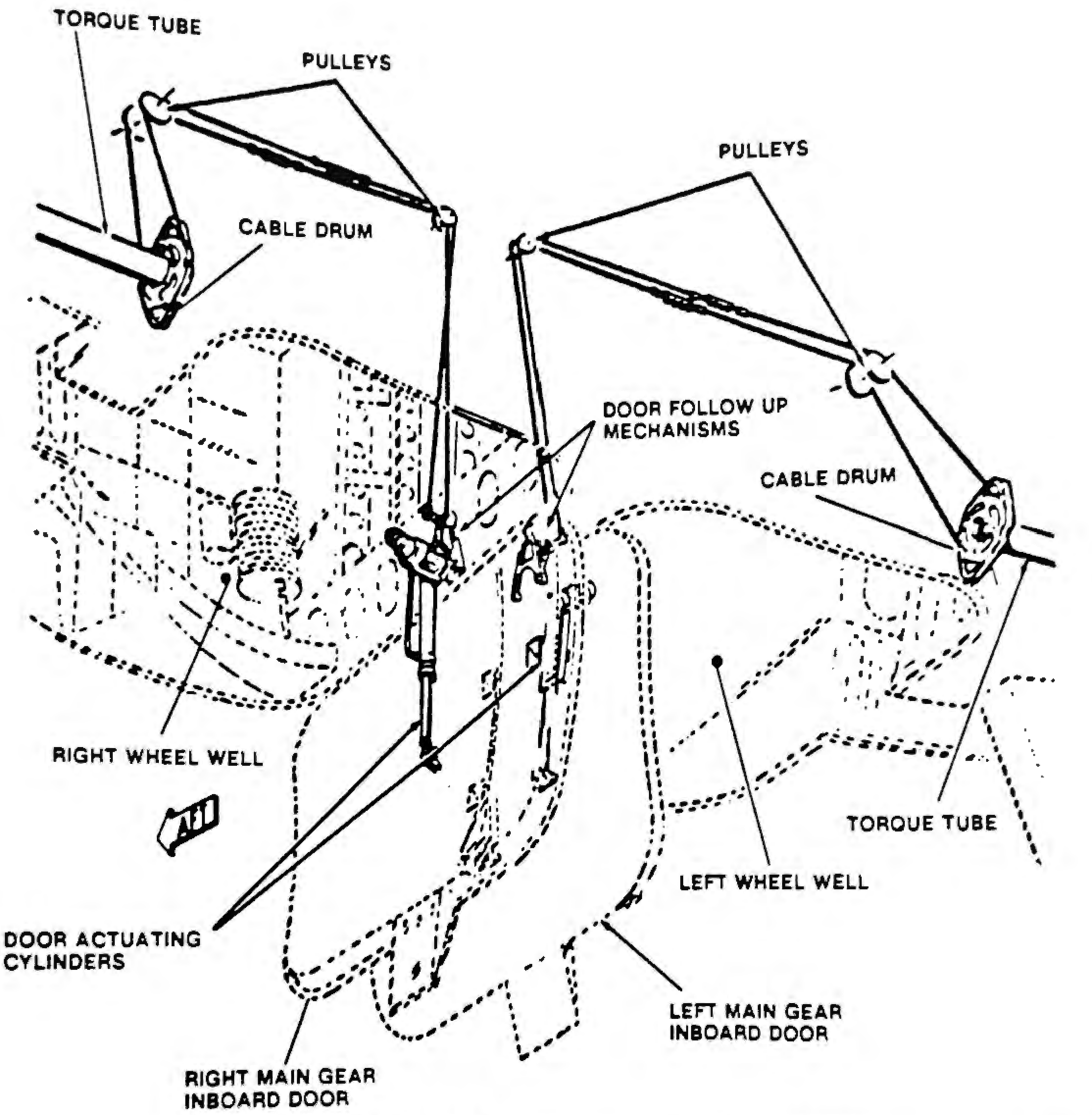
(1) The main gear door followup mechanisms are mechanical means of sequencing the opening and closing of the main gear inboard doors to the cycling of the main gear. They are actuated by the main gear torque tubes.

(2) One followup mechanism is located in each main gear wheel well. The drive sector is installed on the inboard end of each torque tube and is connected to the control valve actuator by a closed circuit cable run.

(3) The control valve actuator consists of a support bracket, a followup bellcrank or cable crank, and linkage. The support bracket mounts the followup bellcrank and the clevis fitting of the door retract cylinder. The shaft of the swivel gland is the trunnion bolt for the cylinder. A boss is provided on the support bracket to which the swivel gland torque arm is attached. Studs are provided to attach the pivot of the idler link and the idler link spring. The cable crank has a clevis fitting on one end and a trunnion on the other end which pickup the ends of the sequence cables.

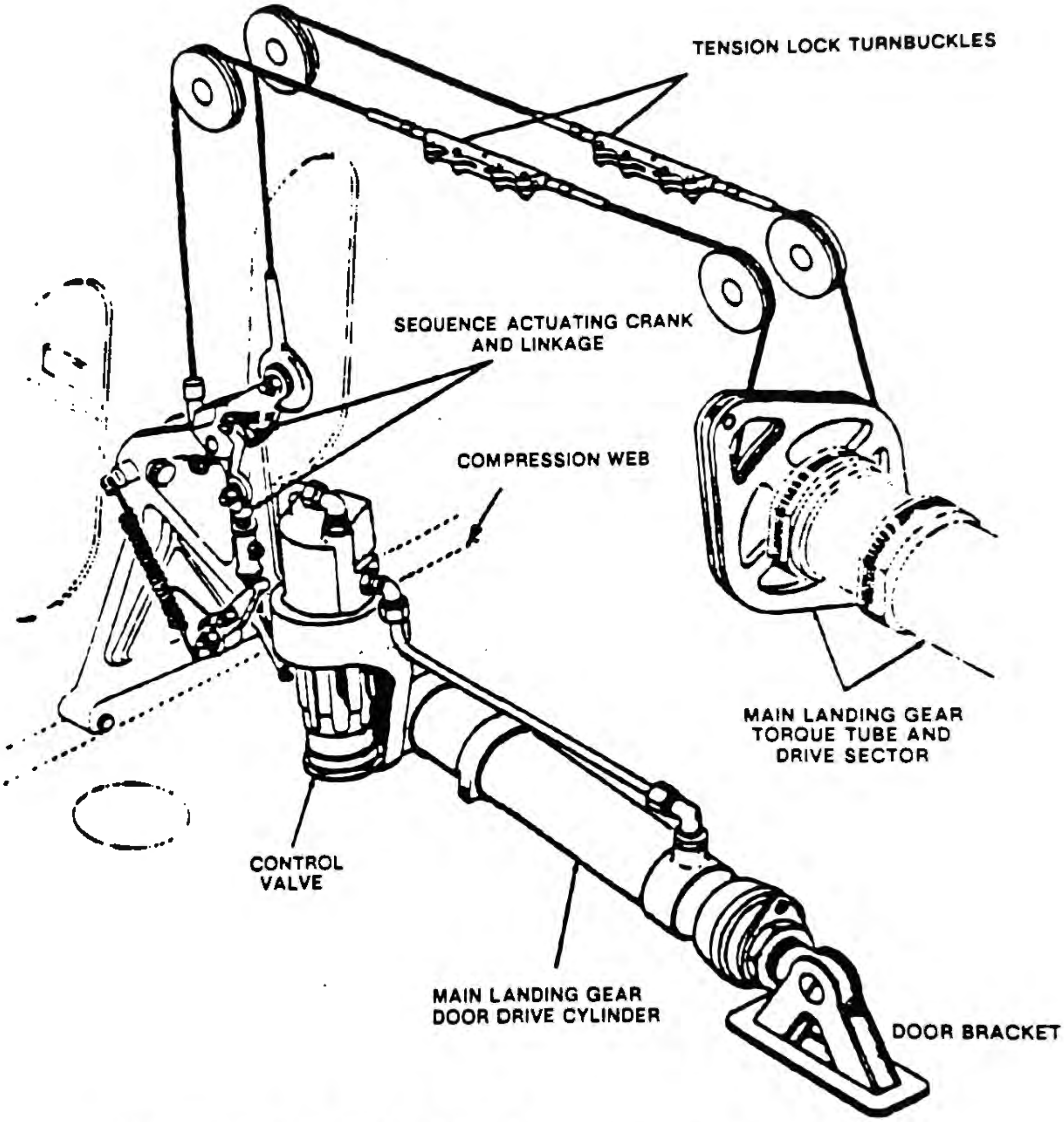
(4) A drive lever, located at the center pivot of the cable crank, attaches to the control valve adjustable link. The adjustable link connects to the idler link and the control valve link. The control valve link connects to the eccentric stud on the control valve crank. The idler link pivots on the cable crank and attaches to the union between the adjustable link and the control valve link. The idler link has a lug for measuring rig adjustments and an arm to spring-load the linkage to the open position.

(5) During main gear retraction, the torque tubes rotate the drive sectors. Through the cable system, the followup bellcrank, or cable crank, is rotated. The first 11-1/2 degrees of torque tube rotation positions the door control valve slide in the door open position. The door then opens and remains open through the next 69-1/2 degrees of torque tube travel because the linkage idles around the idler link. During the next 17 degrees of rotation the linkages position the slide in the door closed position, and the door closes. During the extension cycle, the reverse sequence is accomplished.



MAIN GEAR DOOR FOLLOW UP MECHANISM FTX80120

Figure 32-21


TENSION LOCK TURNBUCKLES
SEQUENCE ACTUATING CRANK AND LINKAGE
COMPRESSION WEB
MAIN LANDING GEAR TORQUE TUBE AND DRIVE SECTOR
CONTROL VALVE
MAIN LANDING GEAR DOOR DRIVE CYLINDER
DOOR BRACKET

MAIN LANDING GEAR DOOR FOLLOW UP MECHANISM FTX80121

Figure 32-22

F. Nose Gear Uplatch Mechanism (See Figure 32-23)

(1) The nose gear uplatch mechanism is a mechanical means of holding the nose gear in the retracted position. It is mechanically actuated to the latch position, and hydraulically or mechanically actuated to the unlatched position. The uplatch mechanism is located on the aft bulkhead in the nosewheel well.

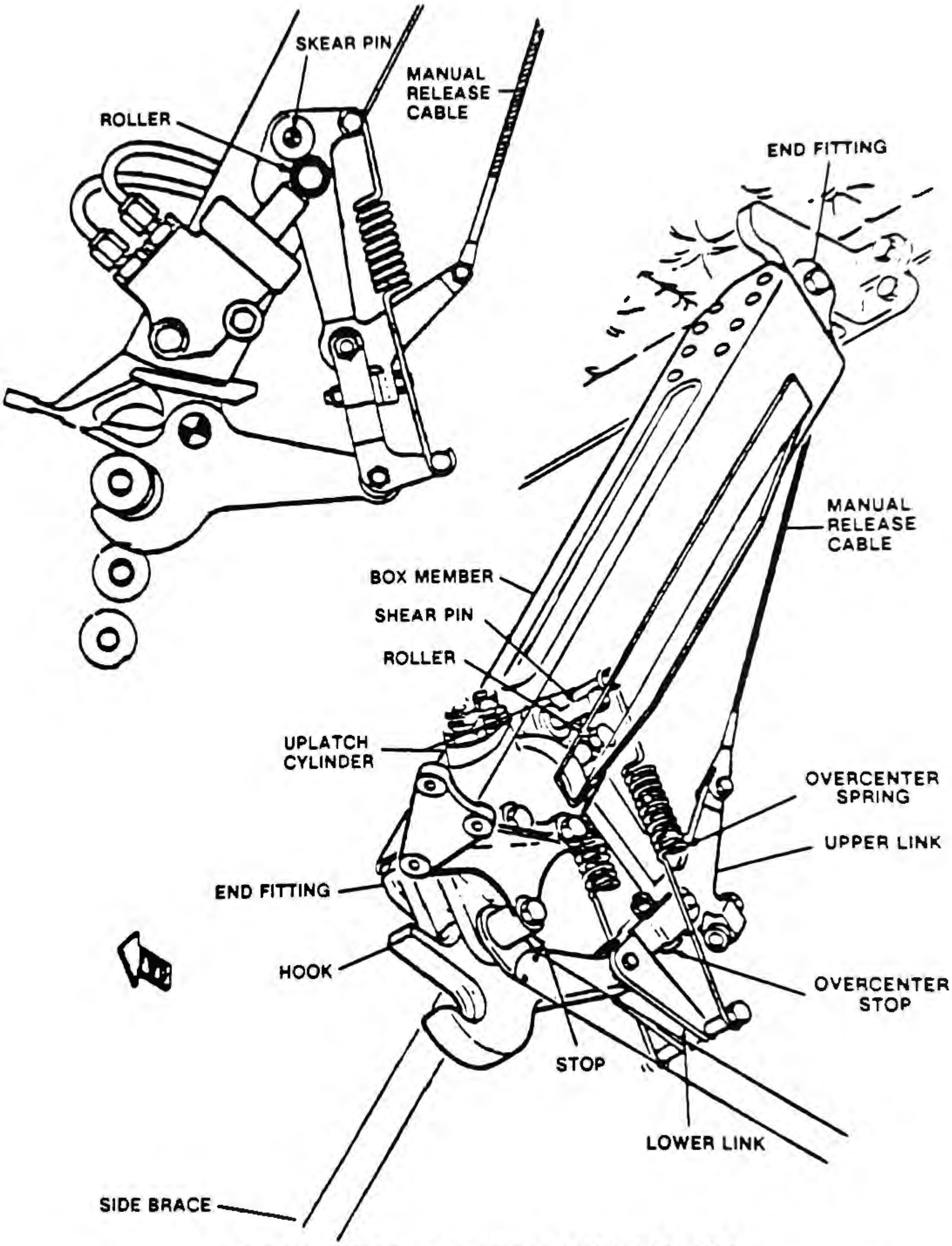
(2) The uplatch mechanism consists of a support, hook, hydraulic cylinder, and overcenter linkage assembly. The overcenter link assembly consists of two links and dual overcenter springs.

(3) When the nose gear is in the uplatch position, the overcenter links are in the extended position, and the hook is pivoted around the uplatch pin in the nose gear drag links to hold the gear up. The links are locked overcenter and held by spring tension. The more weight the gear applies to the hook, the tighter the links are locked.

(4) When the gear is to be extended, hydraulic pressure is applied to the uplatch cylinder which pushes against the rollers and unlocks the links from overcenter. The uplatch cylinder and the weight of the nose gear on the hook continue to fold the links until the uplatch pin on the drag links disengages from the hook and the gear extends.

(5) With the center point of the links folded beyond the center axis of the dual springs, spring tension holds the hook in the ready position. When the gear is retracted, the uplatch pin strikes the latching cam and unfolds the links. When the links reach full extension, the dual overcenter springs actuate and hold the links against their stops.

(6) If a hydraulic failure should occur, the uplatch can be released by a cable attached to the upper link. The cable unlocks the links from overcenter and folds them until the hook is in the unlatched position to allow the gear to free-fall. The cable is actuated by the long lever of the landing gear control lever.



NOSE GEAR UPLATCH MECHANISM

FTX80122

Figure 32-23

G. Nose Gear Safety Couplings (See Figure 32-24)

(1) The nose gear safety coupling is a mechanical means of coupling the nose gear control valve control drum with the nose gear bypass valve control drum.

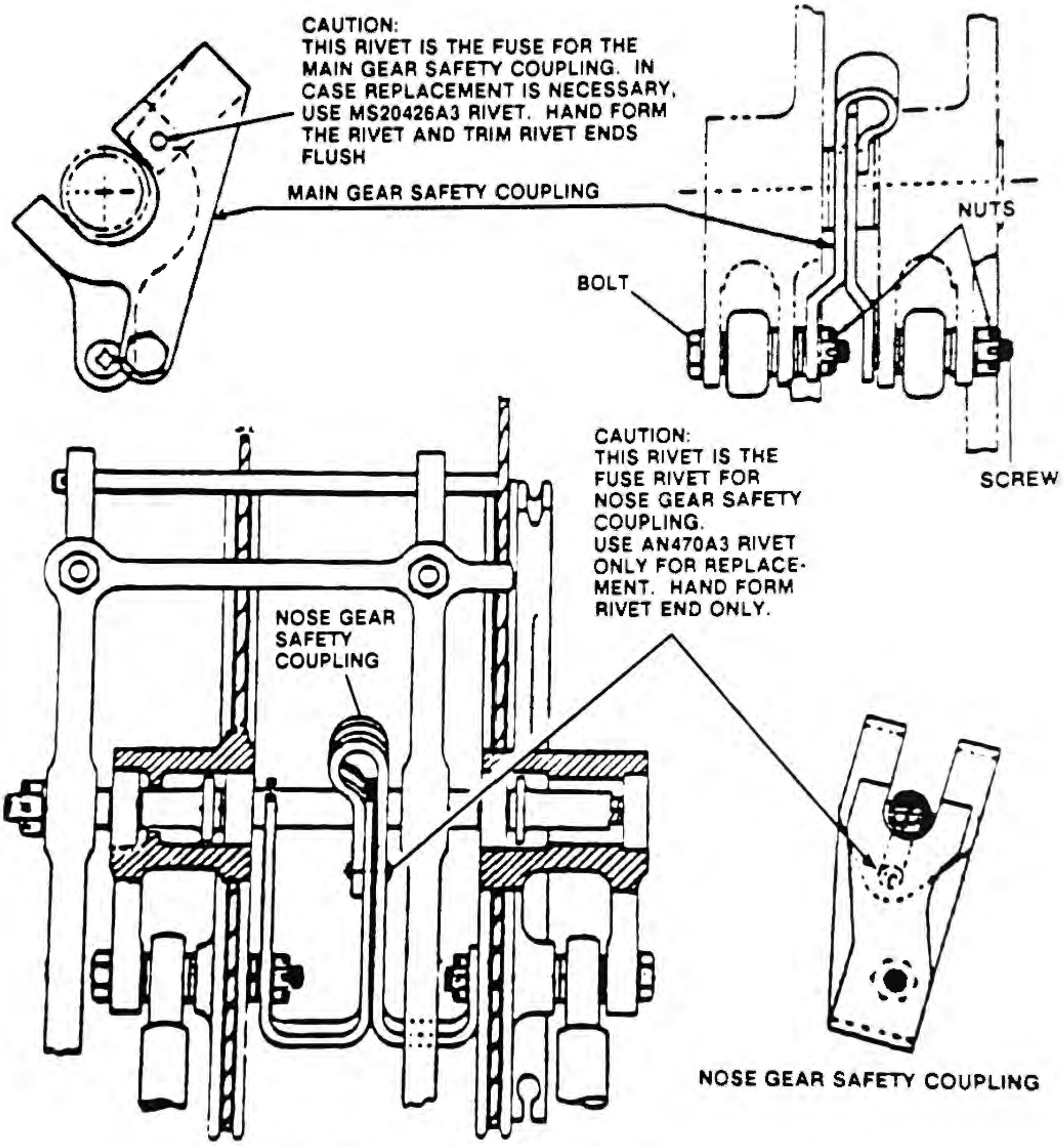
(2) The safety coupling consists of two U-shaped arms riveted together with one rivet. The outer arms of the coupling connect to the valve control drum and the uplatch control drum. The safety coupling prevents a landing gear extension due to a rigging cable failure.

(3) If the landing gear control levers are split and used to lower the gear, the fuse rivet will shear and must be replaced before the next flight. The rivet will shear when one lever is held rigid and the other lever is moved. Approximately 50 pounds of force is required to shear the fuse rivet using the long lever and approximately 80 pounds of force using the short lever.

H. Main Gear Safety Coupling (See Figure 32-24)

(1) The main gear safety coupling is a mechanical means of coupling the main gear control valve drum with the main gear bypass valve drum. The safety coupling consists of two U-shaped arms riveted together with one rivet. The outer arms of the coupling connect to the bypass drum and the control drum. The safety coupling prevents a landing gear extension due to a rigging cable failure.

(2) If the landing gear control levers are split and used to lower the gear, the fuse rivet will shear and must be replaced before the next flight. The fuse rivet will shear when one lever is held rigid and the other lever is moved. Approximately 50 pounds of force is required to shear the fuse rivet using the long lever and approximately 80 pounds of force using the short lever.


CAUTION:
THIS RIVET IS THE FUSE FOR THE MAIN GEAR SAFETY COUPLING. IN CASE REPLACEMENT IS NECESSARY, USE MS20426A3 RIVET. HAND FORM THE RIVET AND TRIM RIVET ENDS FLUSH
MAIN GEAR SAFETY COUPLING
NUTS
BOLT
SCREW
CAUTION:
THIS RIVET IS THE FUSE RIVET FOR NOSE GEAR SAFETY COUPLING.
USE AN470A3 RIVET ONLY FOR REPLACEMENT. HAND FORM RIVET END ONLY.
NOSE GEAR SAFETY COUPLING
NOSE GEAR SAFETY COUPLING

MAIN AND NOSE GEAR SAFETY COUPLINGS FTX80123

Figure 32-24

I. Operation

(1) When the landing gear control lever is placed in the gear up position, the mechanical control system positions the nose gear and main gear control valves to port hydraulic pressure to the main and nose gear downlock bungee cylinders and actuating cylinders. The bungee cylinders unlock the overcenter linkages, and the actuating cylinders retract the gear. When the gear reaches the up position, the uplatches engage and hold each gear in the up position.

(2) During the first few degrees of main gear travel, the main gear door followup mechanism positions the door control valves to the door open position. When the gear is within the last few degrees of travel, the door valves are positioned to the closed position, and the inboard doors close and are engaged in the door uplatches.

(3) After the gear are up and latched, the landing gear control lever may be placed in the uplatch check position to verify latch engagement. This allows the gear to rest on the uplatches. After the uplatch check is satisfactorily accomplished, the landing gear control lever is placed in the gear up position to hydraulically hold the gear weight off the latches.

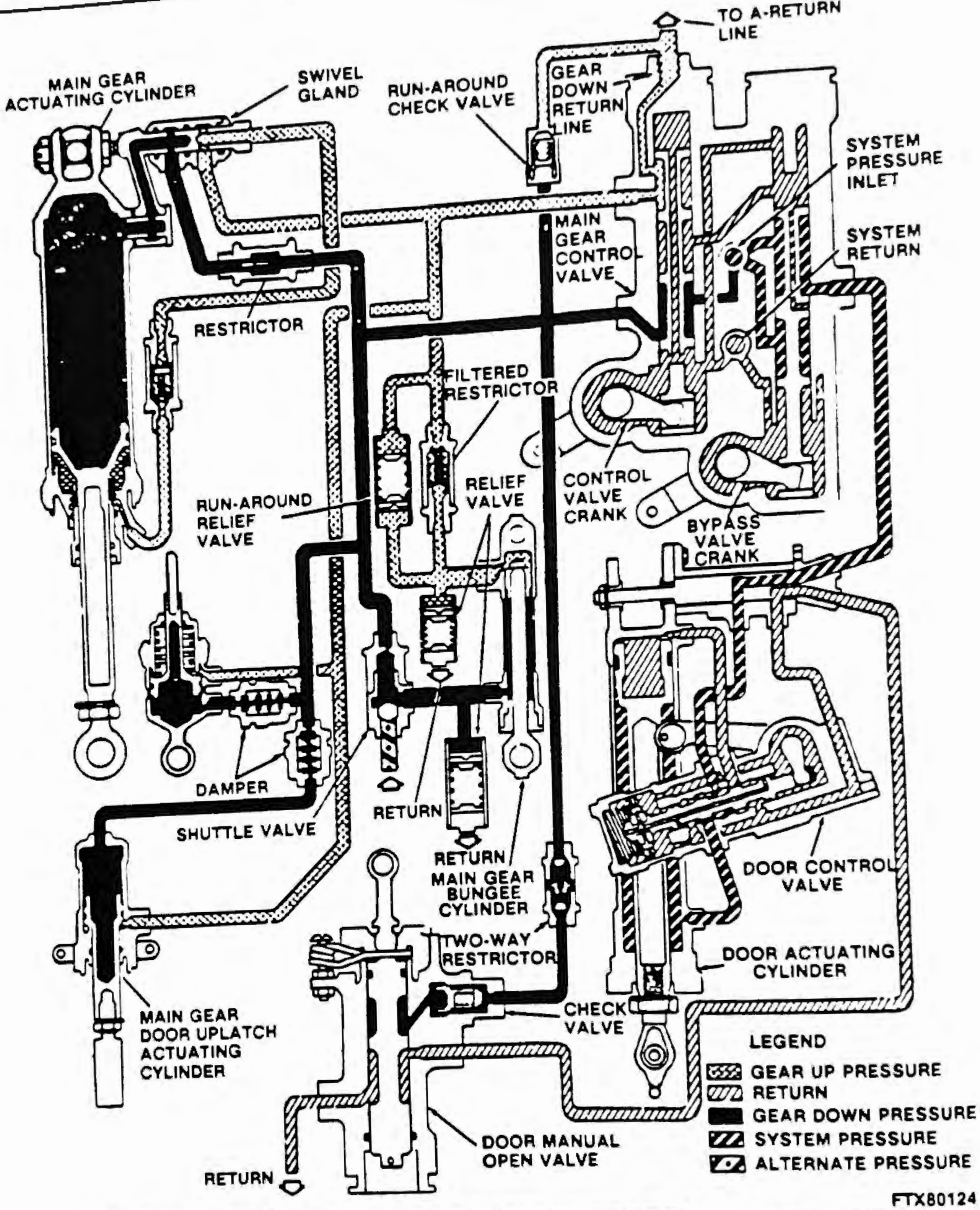
6. Landing Gear Hydraulic Control System - Description and Operation

A. General (See Figures 32-25 & 32-26)

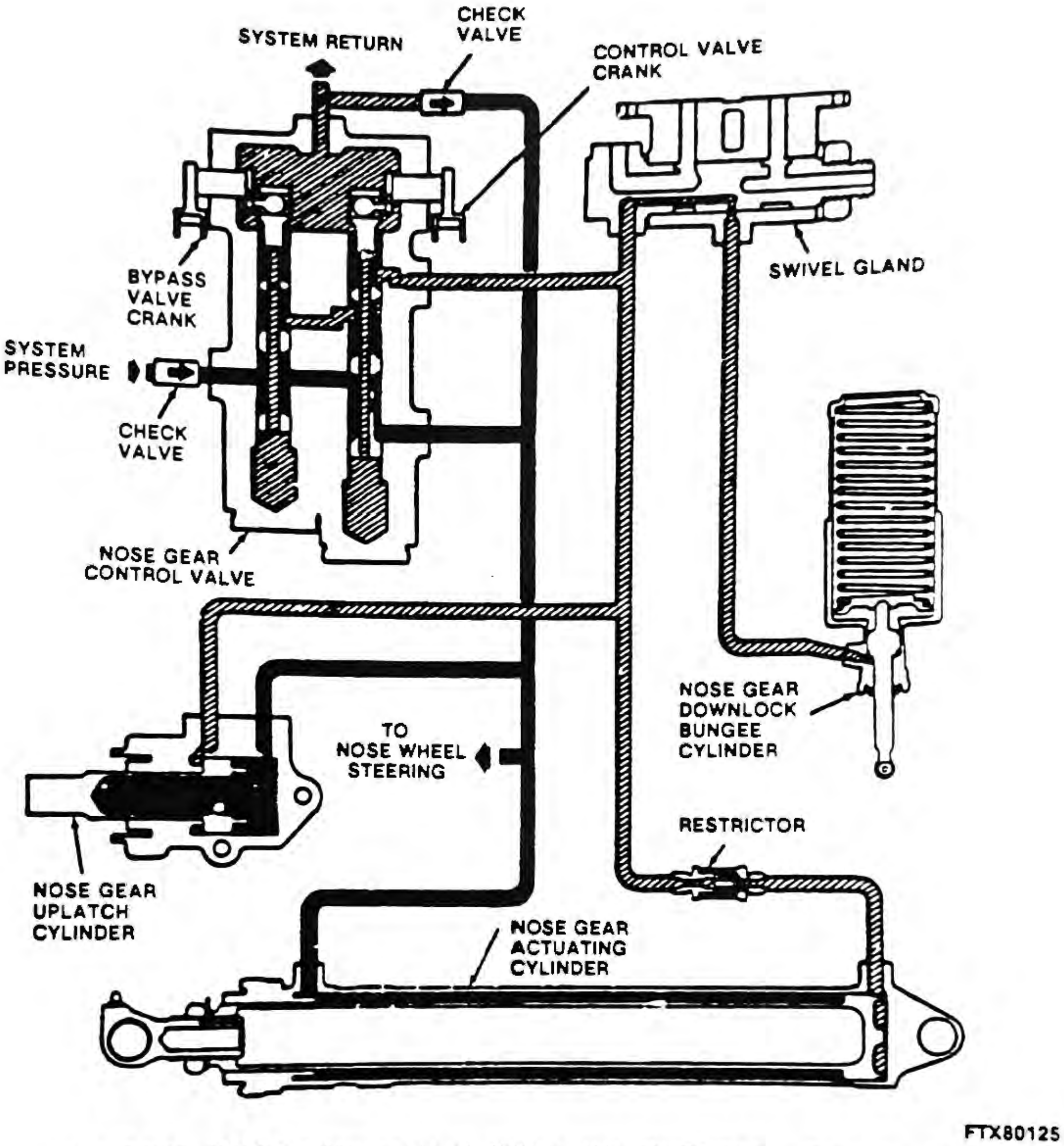
(1) The landing gear hydraulic control system is comprised of two systems: one for the main gear and one for the nose gear.

(2) The main gear hydraulic control system consists of a control valve, two gear actuating cylinders, two gear uplatch cylinders, two gear downlock bungee cylinders, and two downlock bungee cylinder shuttle valves. To actuate the main gear inboard doors, there are two door actuating cylinders and control valve assemblies, and two door uplatch cylinders. A main gear inboard door manual open valve is used to open the doors for access to the wheel wells.

(3) The nose gear hydraulic control system consists of a control valve, gear actuating cylinder, gear uplatch cylinder, and a downlock bungee cylinder.



LANDING GEAR HYDRAULIC CONTROL SYSTEM -- SCHEMATIC
Figure 32-25



LANDING GEAR HYDRAULIC CONTROL SYSTEM -- SCHEMATIC

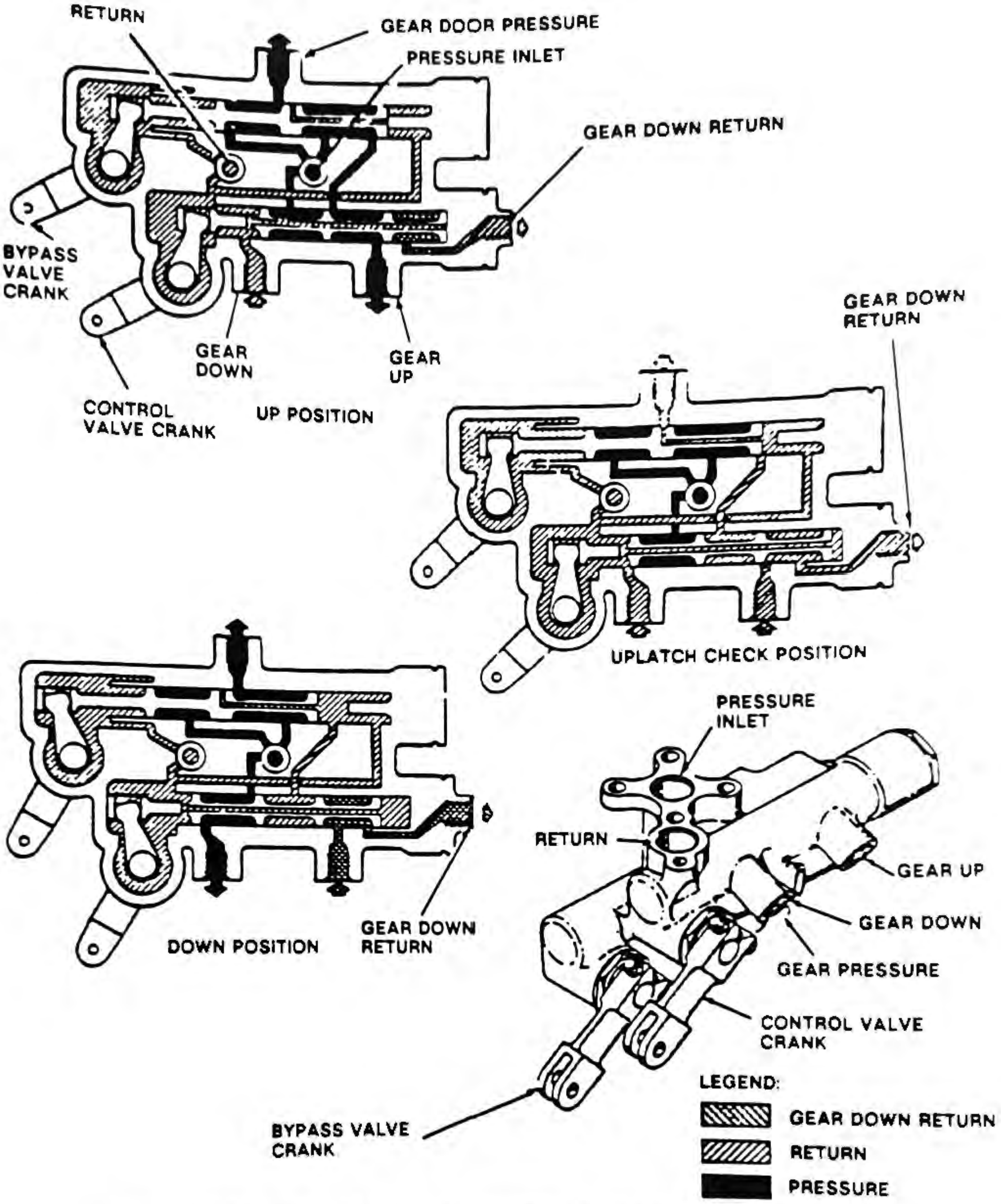
Figure 32-26

B. Main Gear Hydraulic Control Valve (See Figures 32-27 & 32-28)

(1) The main gear control valve is a dual-spooled control and bypass valve used to route hydraulic pressure for extension and retraction of the main gear. The control valve is located on the bottom side of the outboard end of the right power manifold in the right wheel well.

(2) The control valve has six ports: the retract and extend ports, main gear door pressure port, and two drilled (pressure and return) passages of the mounting pad, and the gear down return port. Internally, the valve consists of two slide valves, two actuator cranks, and two sleeve positioning nuts. The control slide spool has two grooves and is installed as an assembly lapped with the ported sleeve. The bypass slide spool has two grooves and an internal passage from the middle land to the end chamber; this slide is also installed as a lapped assembly. The sleeves of both assemblies are secured by sleeve positioning nuts. The actuating crank and lever for each valve are installed as units in the housing. Internal passages connect the two valves.

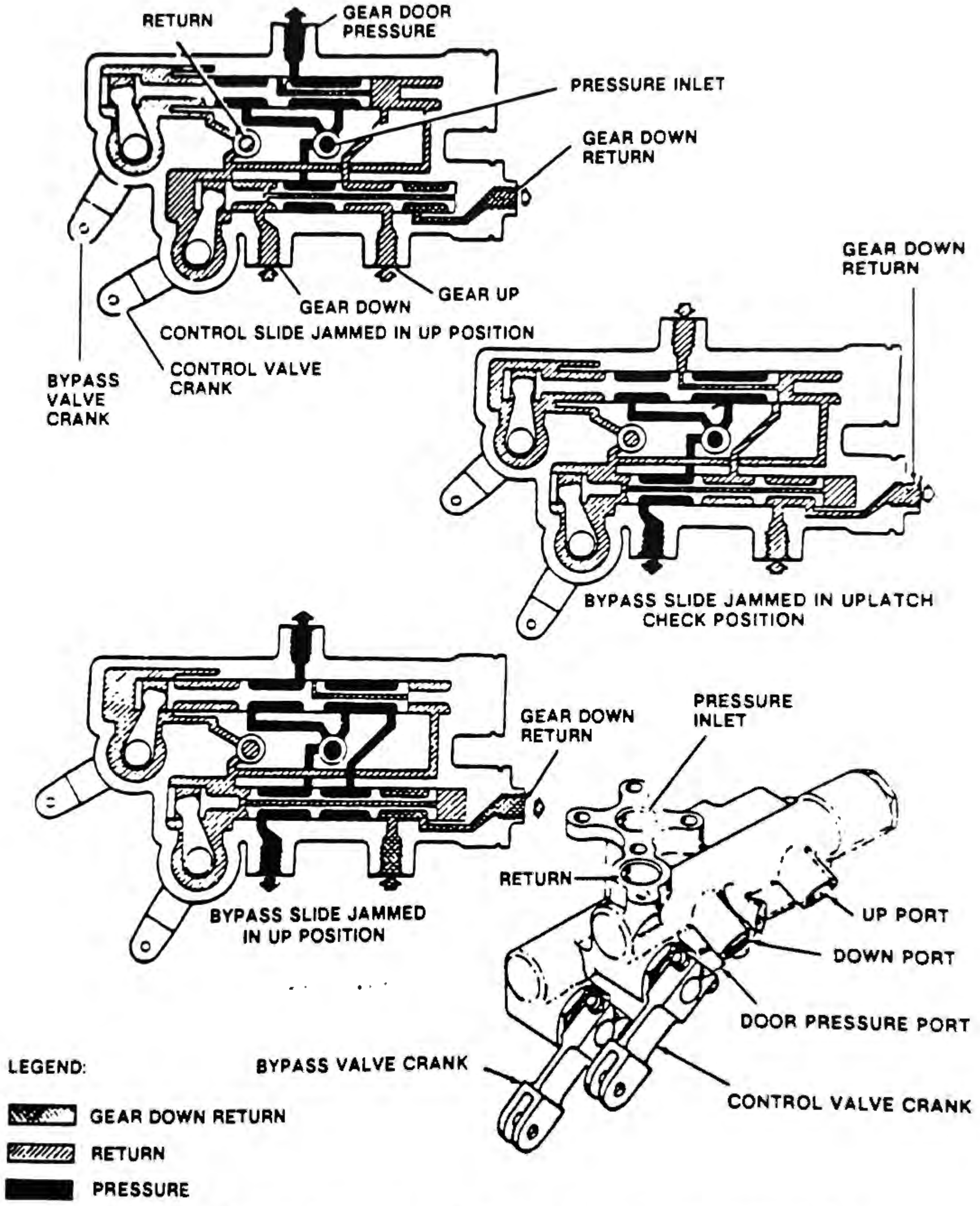
(3) The control valve is actuated by two sectors and pushrods. The control valve spool is actuated by the short lever of the bussed landing gear control lever. The long lever actuates the bypass valve spool. The valve controls three portings: gear up, gear down, and uplatch check.



MAIN GEAR HYDRAULIC CONTROL VALVE-- SCHEMATIC (NORMAL CONDITION)

FTX80126

Figure 32-27



MAIN GEAR HYDRAULIC CONTROL VALVE-- SCHEMATIC
(JAMMED CONDITION)

FTX80127

Figure 32-28

C. Main Gear Actuating Cylinders (See Figure 32-29)

(1) One main gear actuating cylinder is installed in each main gear wheel well parallel to the shock strut. The cylinder barrel is attached to the landing gear support fitting by a special bolt. The piston rod end attaches to a boss-stud on the shock strut.

(2) The actuating cylinder consists of a barrel, piston, gland, and a dash pot damper. The damper consists of a sleeve, retainer, seals, and scraper. The sleeve is cylindrical with 16 grooves (one, the porting groove, is longer) which flute the end of the sleeve extending into the cylinder. Seals in the head end of the sleeve seal the dash pot to the piston rod.

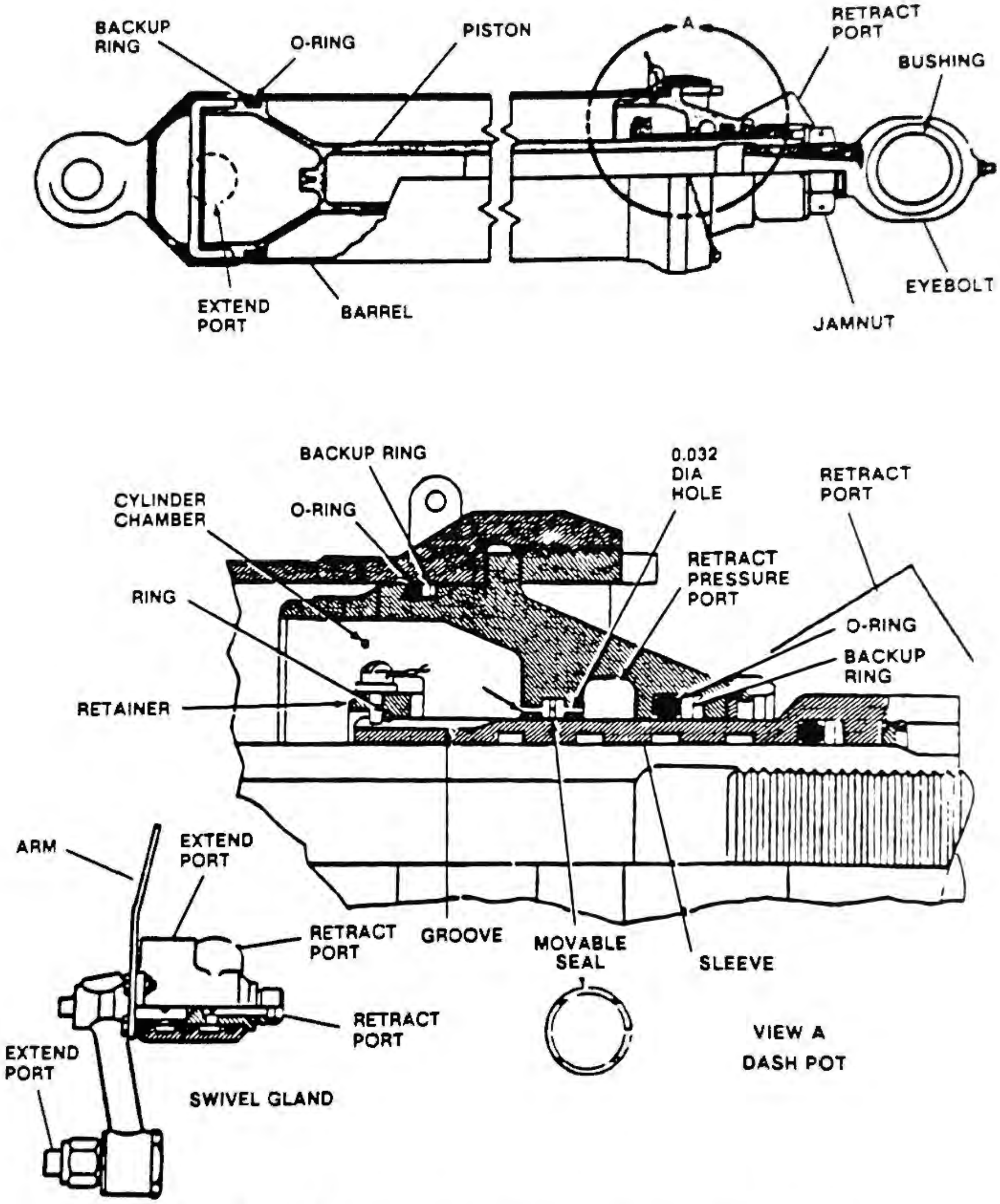
(3) A swivel gland provides a flexible joint for the hydraulic lines and allows the actuating cylinder to rotate around its upper pivot axis.

(4) A 1-way, filtered restrictor is installed in the actuating cylinder retract line. The restrictor allows free flow in the retract direction, but restricts fluid flow in the extension direction.

D. Main Gear Bungee Cylinders (See Figure 32-30)

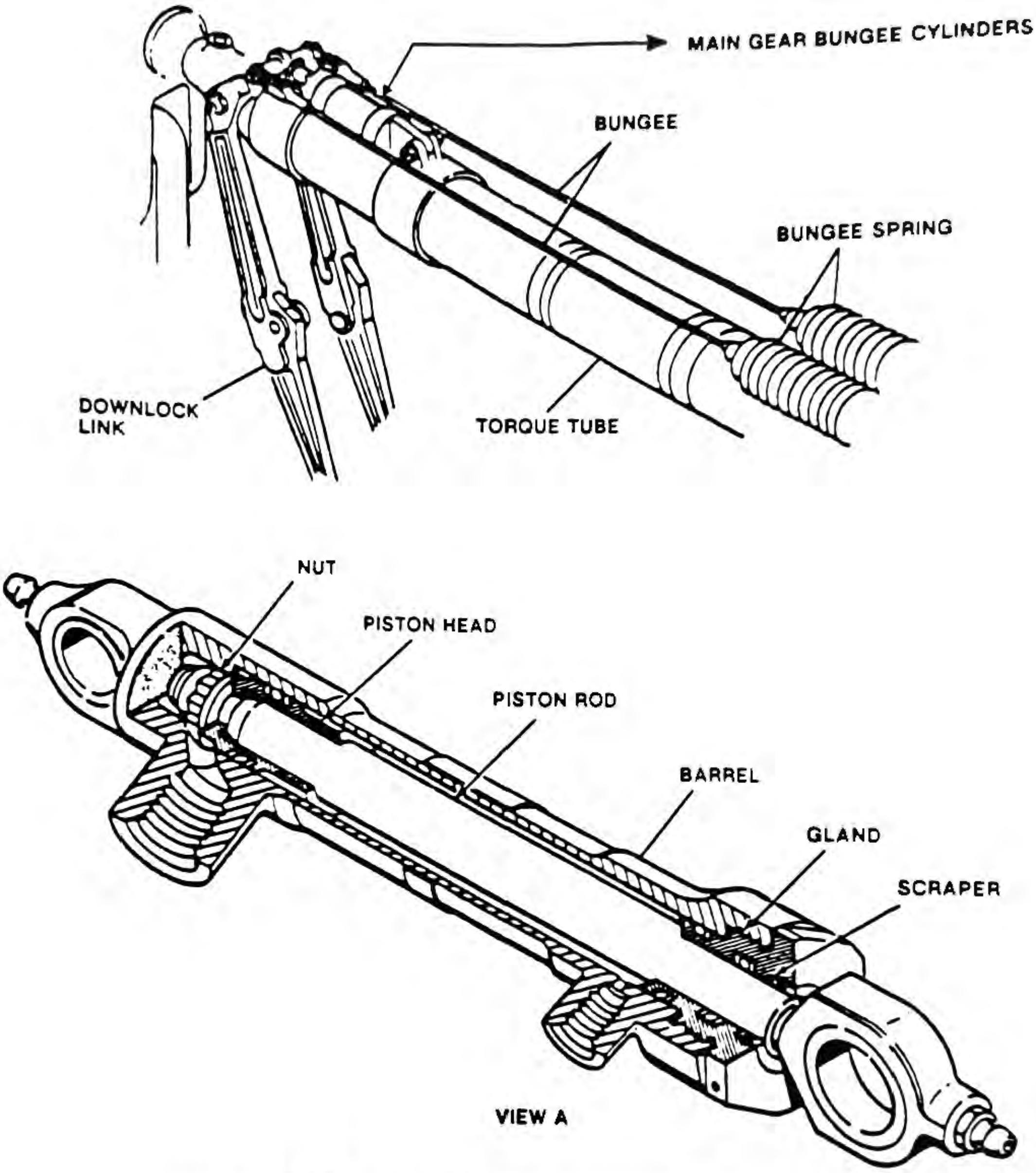
(1) The main gear bungee cylinders are 2-way, hydraulic, actuating cylinders used to overcome bungee spring tension and unlock the overcenter linkage in preparation for gear retraction. During gear extension, the bungee cylinders, in conjunction with the bungee springs, lock the overcenter linkage in the down position.

(2) One bungee cylinder is located on each main gear torque tube and is connected between a trunnion fitting on the torque tube and the actuating arms of the upper overcenter links. The piston rod end is attached to the overcenter links with a special bolt; the downlock bungee spring cables also attach to this special bolt. Fluid is ported to the bungee cylinders through high pressure flexible hoses.



MAIN GEAR ACTUATING CYLINDER -- CUTAWAY FTX80128

Figure 32-29



MAIN GEAR BUNGEE CYLINDERS -- CUTAWAY FTX80129

Figure 32-30

E. Main Gear Bungee Cylinder Relief Valves

(1) The bungee cylinder relief valves are connected to two fittings in the gear up pressure system. One bungee cylinder relief valve, pressure set at 3600 psi, relieves excessive system pressure which may result from a main gear retract cylinder failure. The second bungee cylinder relief valve, pressure set at 2350 psi, relieves system pressure which may prevent damage to bungee cylinder during an unrestrained free fall of main landing gear. This valve also relieves pressure which could be caused by a clogged restrictor check valve.

F. Main Gear Bungee Cylinder Shuttle Valve (See Figure 32-31)

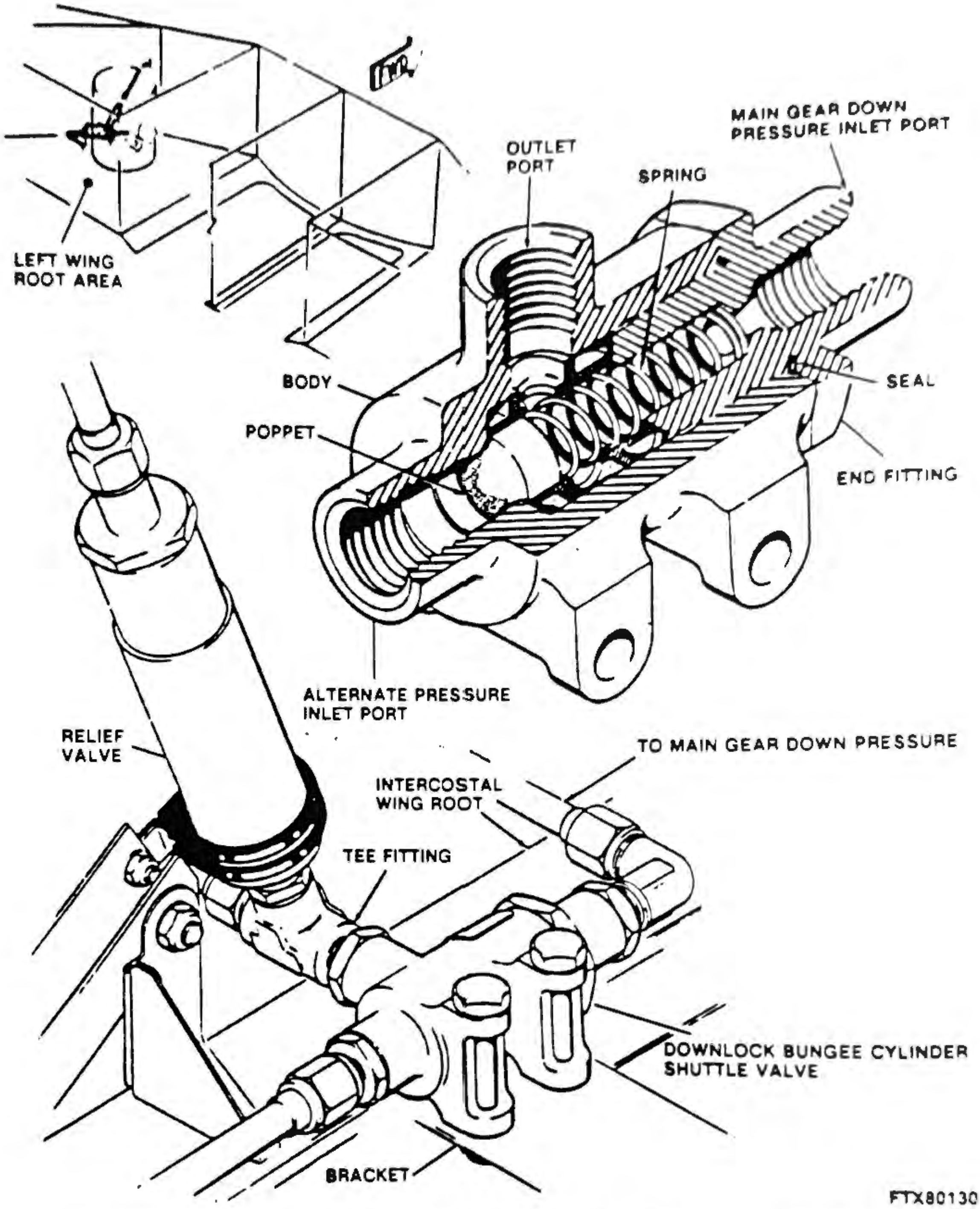
(1) The main gear bungee cylinder shuttle valves are hydraulically actuated, fluid-distributing valves used to port fluid from the main gear control valve of the alternate port of the systems selector valve to the lock port of the main gear bungee cylinders. One shuttle valve is located on an overhead intercostal in each wing root area.

(2) The shuttle valve consists of a body and a spring-loaded shuttle. There are three ports on the shuttle valve. The end ports are for main gear downlock pressure and alternate system pressure. The portion on the center of the body is the common outlet port. The internal chamber of the body contains a double-coned shuttle, a ported spacer sleeve, packing, and a return spring.

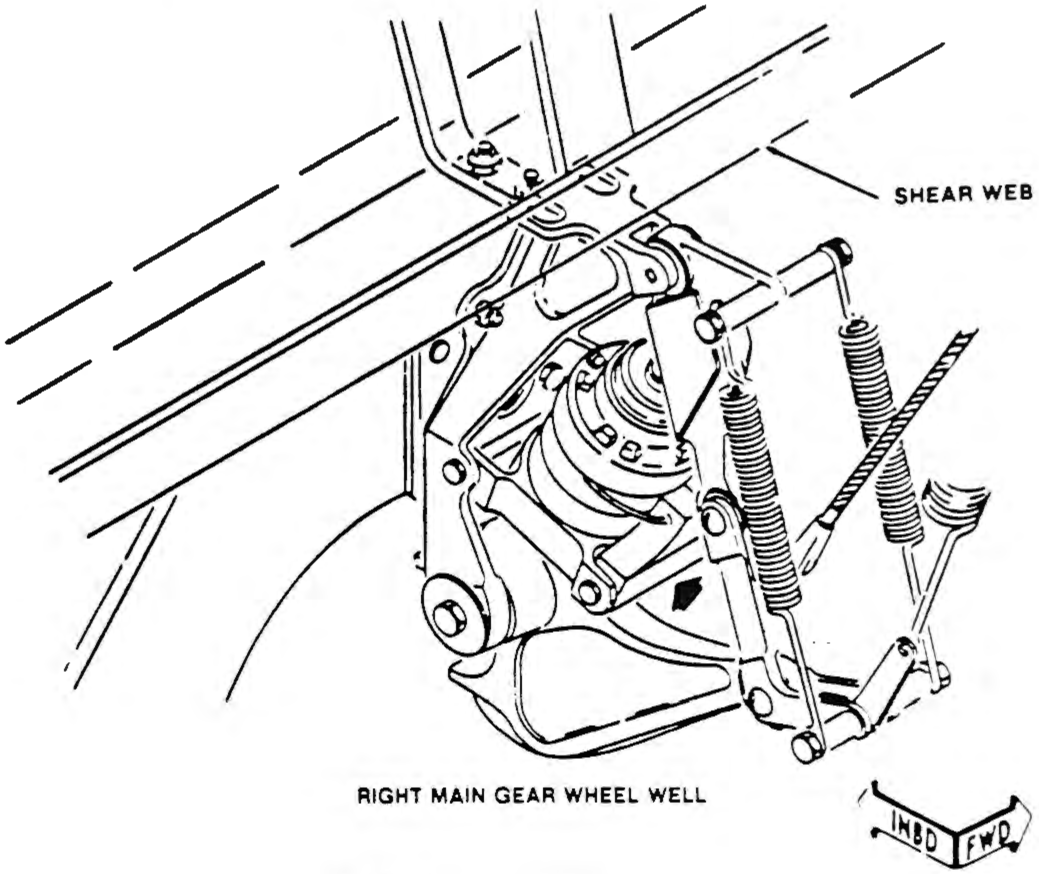
G. Main Gear Uplatch Cylinders (See Figure 32-32)

(1) The main gear uplatch cylinders are 2-way, hydraulic, actuating cylinders used to overcome spring tension and unlock the main gear uplatches. The cylinders are hydraulically actuated in both directions and are springloaded to the retract position.

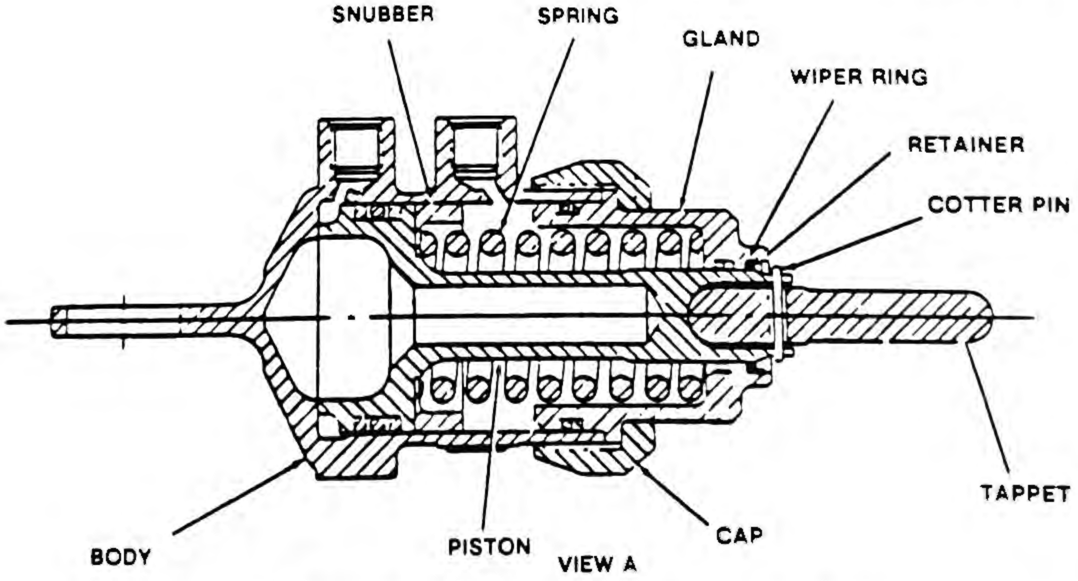
(2) The uplatch cylinder consists of a cylinder, piston, and retract spring. The piston passes through and is sealed by a cup-shaped gland. The gland is retained in the cylinder by a gland nut.



MAIN GEAR BUNGEE CYLINDER SHUTTLE VALVE -- CUTAWAY
Figure 32-31



RIGHT MAIN GEAR WHEEL WELL



VIEW A

MAIN GEAR UPLATCH CYLINDERS -- CUTAWAY FTX80131

Figure 32-32

H. Main Gear Door Uplatch Cylinders (See Figure 32-33)

(1) The main gear door uplatch cylinders are two-way, hydraulic, actuating cylinders used to unlatch the main gear doors. The uplatch cylinder consists of a cylinder and a piston. The piston rod is fitted with a forked end fitting.

(2) During gear retraction, hydraulic pressure is ported to the retract side of the piston head. This holds the forked end fitting clear of the uplatch links, allowing the links to be actuated overcenter by spring tension. During gear extension cycle, the piston is extended to overcome the spring tension on the overcenter links, clears the hook from the door roller, and permits the doors to open. The detent is then positioned to pick up the door roller when the doors are sequenced to the closed position.

I. Main Gear Door Actuating Cylinders (See Figure 32-34)

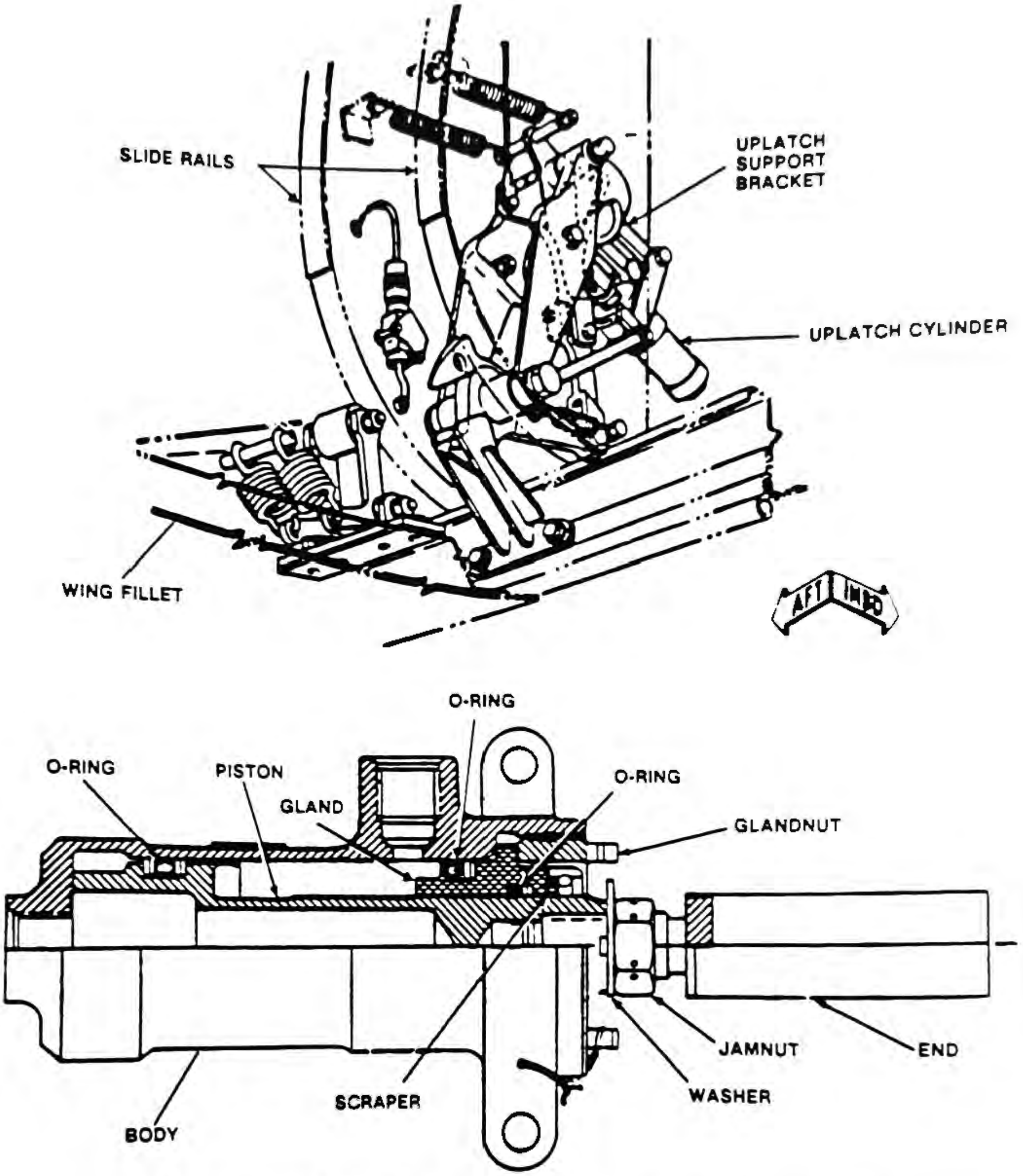
(1) The main gear door actuating cylinders are 2-way, hydraulic cylinders used to open and close the main gear inboard doors during gear retraction and extension cycles. Each cylinder has a control valve and swivel gland assembly mounted at the end of the body.

(2) The control valve is a 4-port, hydraulic valve mounted on the cylinder and used to sequence the door to open and closed positions during gear travel cycles. The control valve consists of a manifold, lap assembly, drive lever, and a crank. The manifold contains four ports: inlet, return, extend, and retract. The manifold also houses the drive lever and crank. The lap assembly consists of a body, slide, and a damper. The slide is spring loaded toward the door open position.

(3) The swivel gland distributes fluid to and from the control valve during door cycling. The swivel gland shaft secures the door actuating cylinder barrel to the door followup mechanism bracket. A flange on the swivel gland body attaches to the actuating cylinder to rotate the swivel gland with the actuating cylinder.

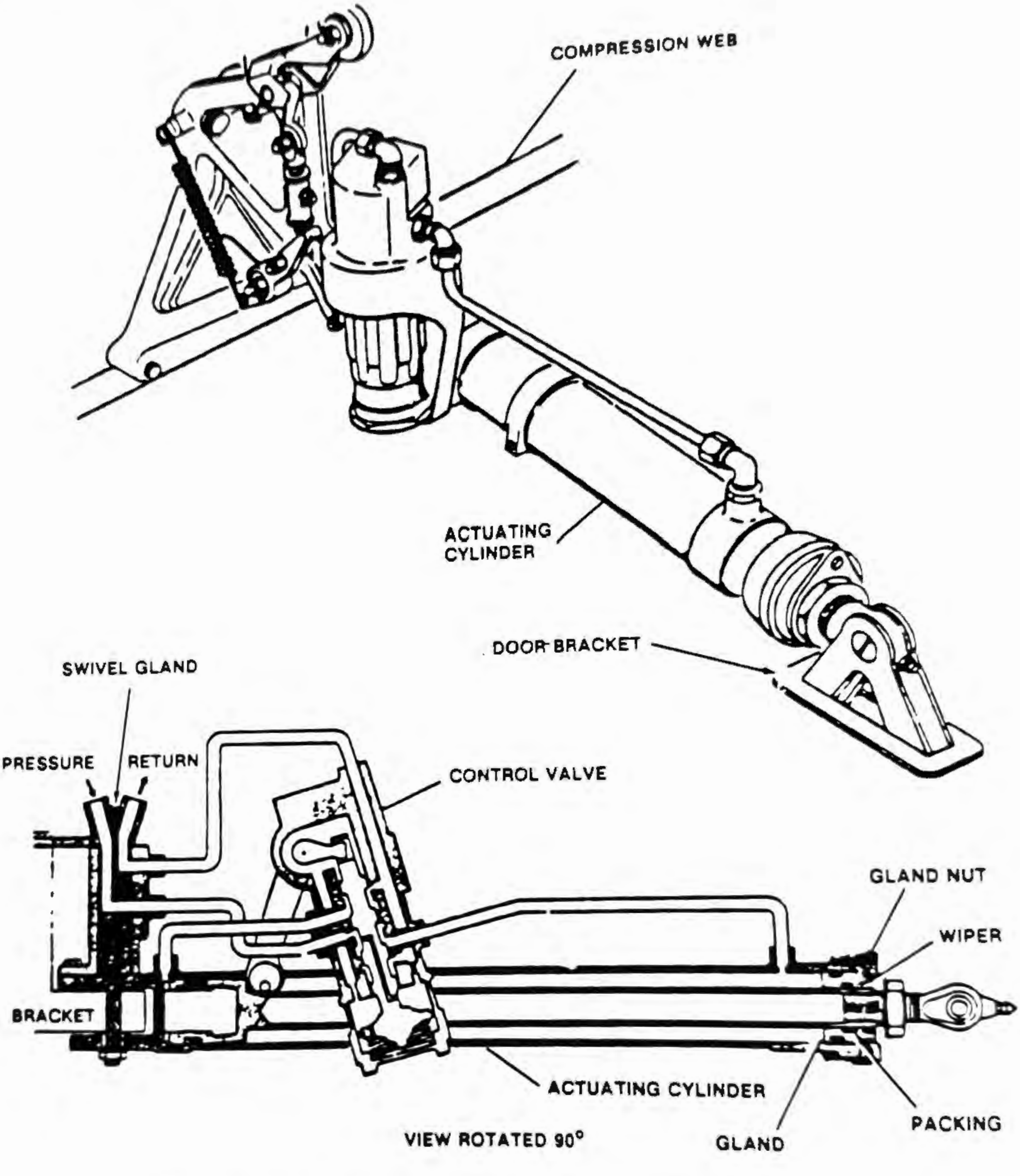
(4) Should a cable failure occur in the door followup mechanism, the control valve actuator linkage, spring loaded to the door open position, will port hydraulic pressure to open the inboard doors, and the doors will open when the latches are released.

(5) By placing the door manual open valve lever in open position, fluid pressure from the main landing gear downline is ported to the return port of the door control valve. This ports hydraulic system pressure to both sides of the door actuating cylinder piston. The force differential, due to the difference in area between the piston head and the piston rod, extends the cylinder to open the inboard door. The door closes when the manual open valve is returned to the closed position.



MAIN GEAR DOOR UPLATCH CYLINDERS -- CUTAWAY FTX80132

Figure 32-33



MAIN GEAR DOOR ACTUATING CYLINDER -- CUTAWAY FTX80133

Figure 32-34

J. Main Gear Door Manual Open Valve (See Figure 32-35)

(1) The main gear door manual open valve is a 2-position, 3-port, hydraulic control valve used to open the main gear inboard doors manually, when the airplane is on the ground. The valve is located in the left wing root area on the lower aft intercostal near the hydraulic reservoir. The actuating lever extends into the strut area of the main gear wheel well.

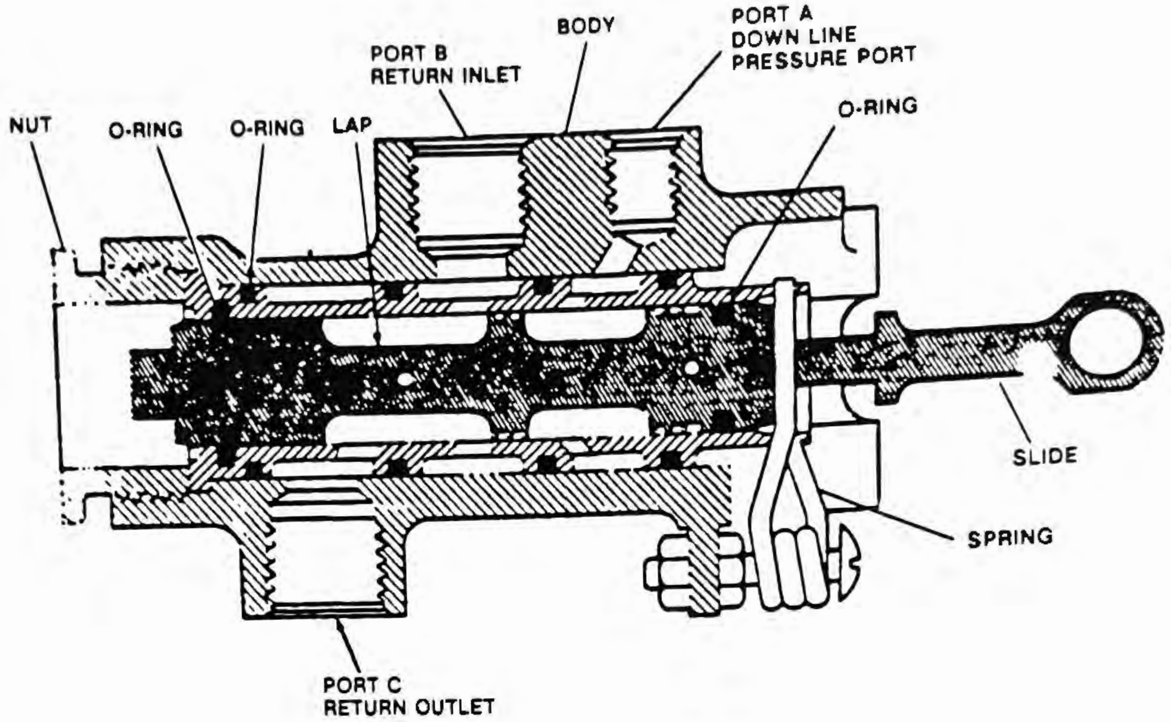
(2) A reverse flow check valve is installed in the main gear downline port of the manual open valve so that it will function as a gust lock when the doors are open and power is off the airplane. A 2-way flow restrictor is installed upstream of the check valve to slow the door opening speed as a safety measure.

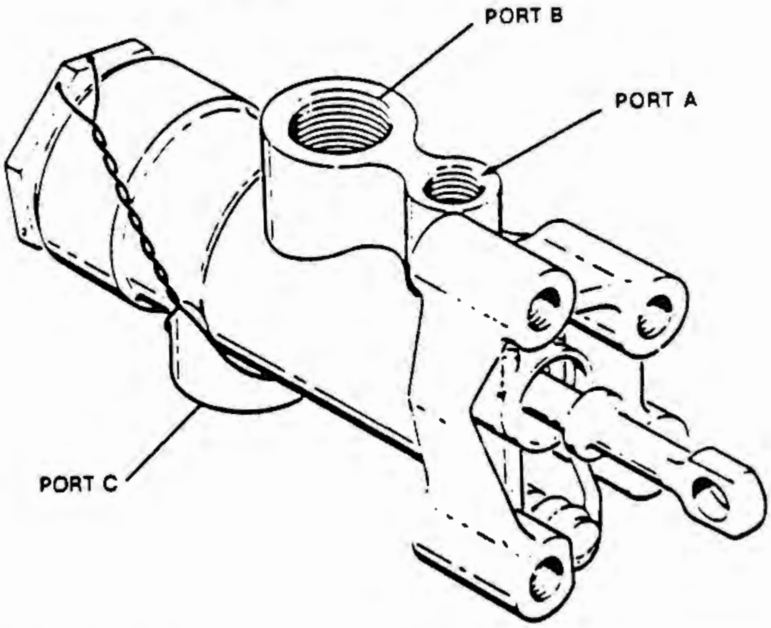
(3) The door manual open valve may be actuated to open the main gear inboard door for service when the airplane is on the ground. Normally, the valve is positioned to port the return fluid from the door control valve to the reservoir. To open the inboard door with the gear extended, the door open valve actuating lever is pulled down to push the slide in the valve to the open position . The doors are closed by returning the lever to the door (normal) detent. If the lever is left in the door open detent, the left main gear center door will return the lever to normal position when the gear is retracted.

K. Main Gear Swivel Gland (See Figure 32-36)

(1) The main gear swivel glands are flexible joints with internal passages for hydraulic fluid. The hydraulic lines are routed to the power brakes and the bogie trim cylinders.

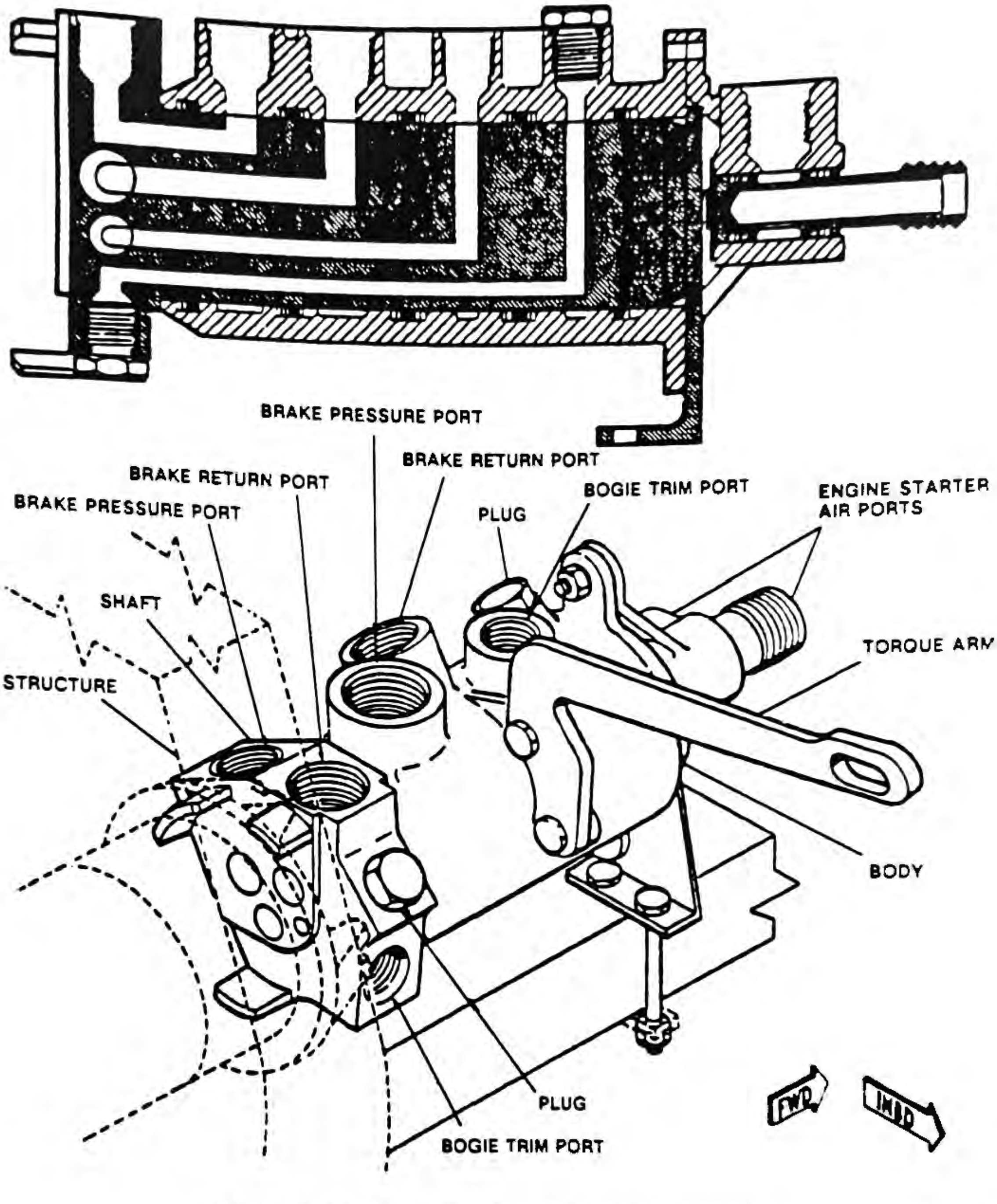
(2) The hydraulic swivel gland consists of a body, shaft, and a torque arm. The body is cylindrical in shape and has four staggered ports. An anchor flange for the torque arm is on the lower side of the body. The body is grooved internally to port fluid and to retain seals. The torque arm is L-shaped and attaches to the anchor flange at one end and to a bracket on top of the gear strut. The bracketed end plate holds the swivel gland shaft stationary, allowing the body to be pivoted around the axis of the shaft by the torque arm. This provides a flexible joint for the hydraulic lines when the gear is cycled.





MAIN GEAR DOOR MANUAL OPEN VALVE -- CUTAWAY FTX80134

Figure 32-35



MAIN GEAR SWIVEL GLAND -- CUTAWAY

FTX80135

Figure 32-36

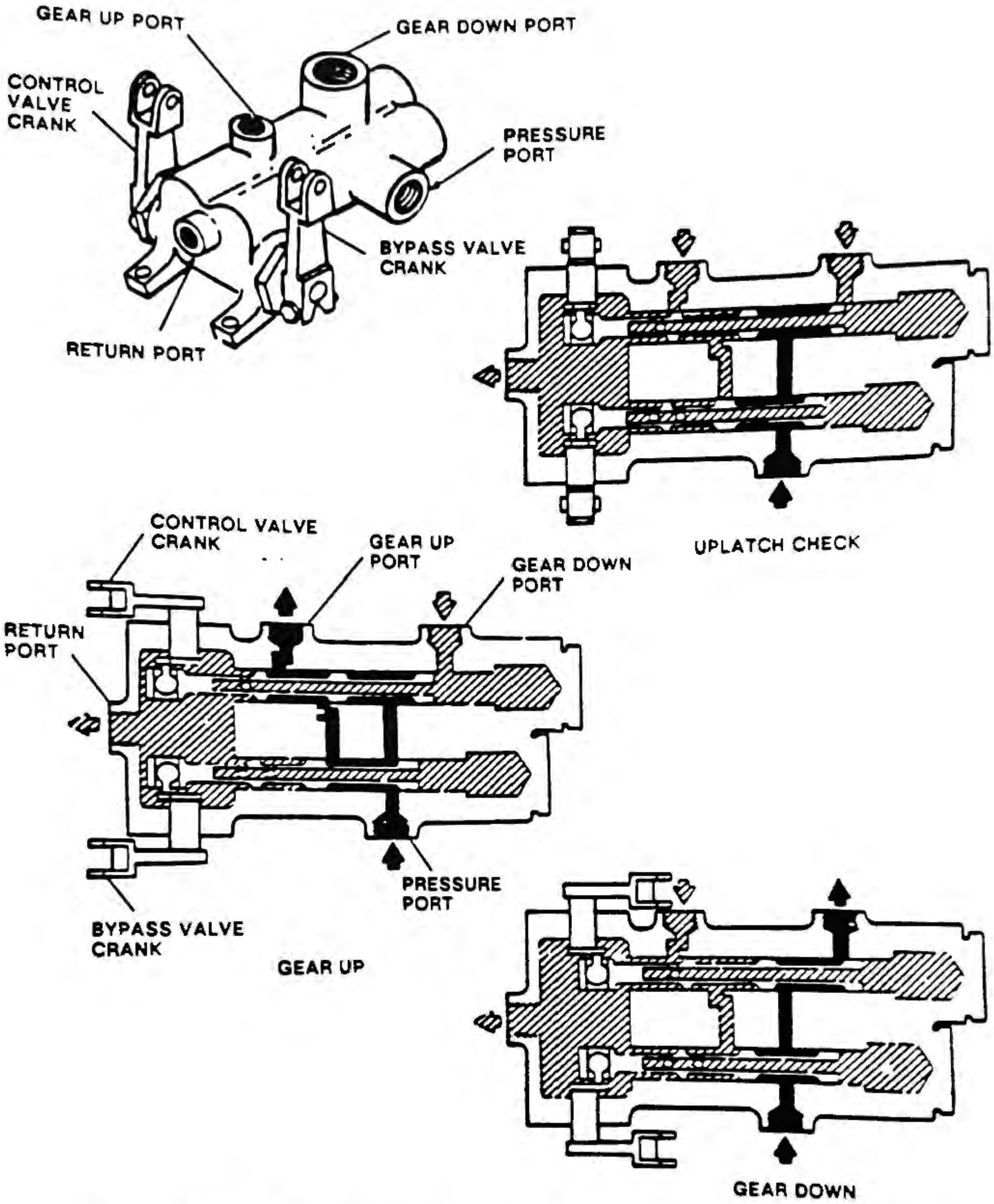
L. Nose Gear Hydraulic Control Valve (See Figures 32-37 & 32-38)

(1) The nose gear control valve is a dual-spool control and bypass valve used to route pressure for nose gear extension and retraction.

(2) The control valve body consists of external ports and two actuating levers. The valve body has four ports: the extend and retract ports, and the system pressure and return ports. Internally, the valve consists of two slide valves, actuator cranks, and sleeve positioning nuts. The control valve spool has two grooves and has an internal passage connecting the ends. The bypass valve spool also has two grooves; the ends and the first groove of the spool are connected by an internal passage. The ported sleeve and slide of both the control and bypass valves are installed as lapped assemblies. The sleeves of both assemblies are secured by sleeve positioning nuts. The actuating crank and lever assemblies for the valves are installed as a unit in the crank housing. Internal passages connect the two valves.

(3) The nose gear control valve is designed to make it possible to extend the nose gear if either slide spool becomes jammed in any position other than normal down. If the control slide spool should become jammed in the gear up position, a free-fall extension can be accomplished by splitting the landing gear control levers and placing the long lever in down position. In this position, the bypass slide ports the upline to return through the internal passage in the slide. The control spool ports downline to return. With uplines and downlines ported to return, the gear falls free when the latches are manually released.

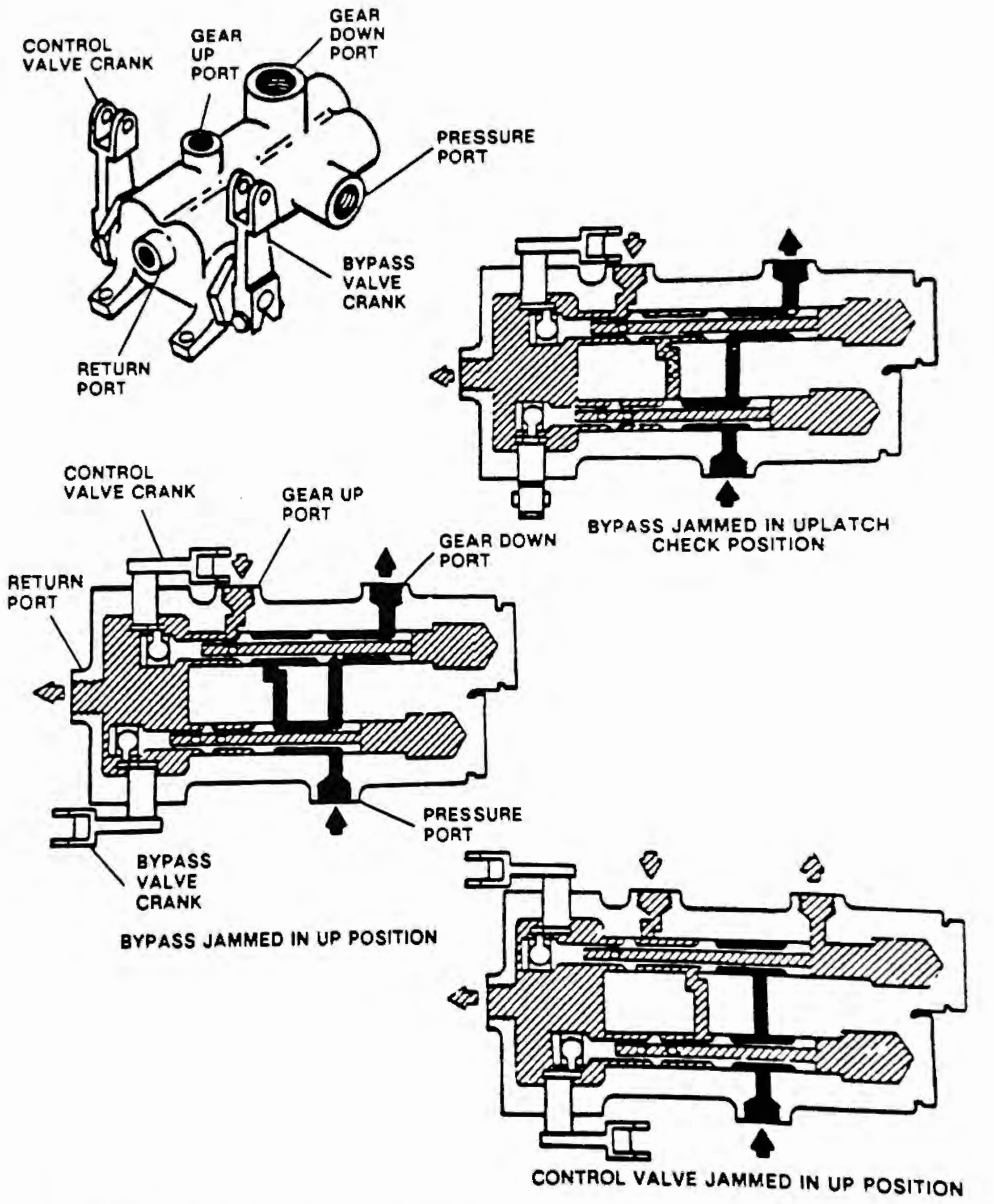
(4) If the bypass spool becomes jammed in the uplatch check position, a power extension can be accomplished by splitting the control lever and placing the short lever in down position. This positions the control slide to the down position, porting pressure to the downline. The control slide ports the upline to return.



NOSE GEAR HYDRAULIC CONTROL VALVE -- SCHEMATIC (NORMAL CONDITIONS)

FTX80136

Figure 32-37



BYPASS JAMMED IN UPLATCH CHECK POSITION

BYPASS JAMMED IN UP POSITION

CONTROL VALVE JAMMED IN UP POSITION

NOSE GEAR HYDRAULIC CONTROL VALVE -- SCHEMATIC
(JAMMED CONDITION)

FTX80137

Figure 32-38

M. Nose Gear Actuating Cylinder (See Figure 32-39)

(1) The nose gear actuating cylinder is a standard, 2-way hydraulic cylinder used to extend and retract the gear. It is a floating cylinder installed between the torque arm of the strut side brace and the drag link. The barrel of the cylinder is attached to the drag link and the piston rod end fitting is attached to the side brace torque arm.

(2) The actuating cylinder consists of a barrel and a piston. The end fitting of the barrel is a clevis type. A bulkhead fitting bracket, used as a connecting point for the hydraulic lines and hoses, is attached to the aft end of the cylinder by a clamp. Metal lines connect the two cylinder ports with the fittings on the bracket.

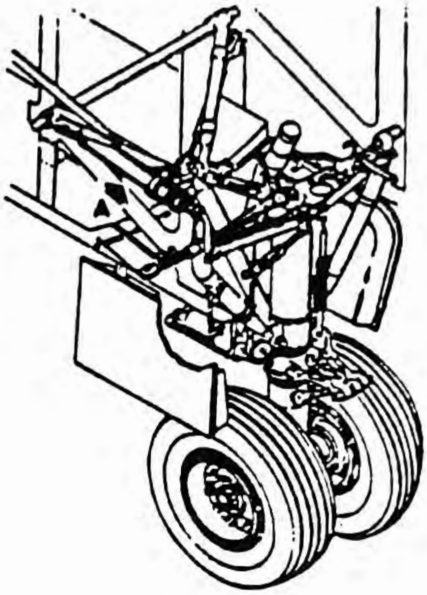
(3) The nose gear actuating cylinder restrictor is a 2-way, filtered hydraulic restrictor used to control the speed of the nose gear extension and retraction. The restrictor is installed on the aft bulkhead of the nosewheel well adjacent to the nose gear control valve. It is installed in the retract line to the nose gear actuating cylinder.

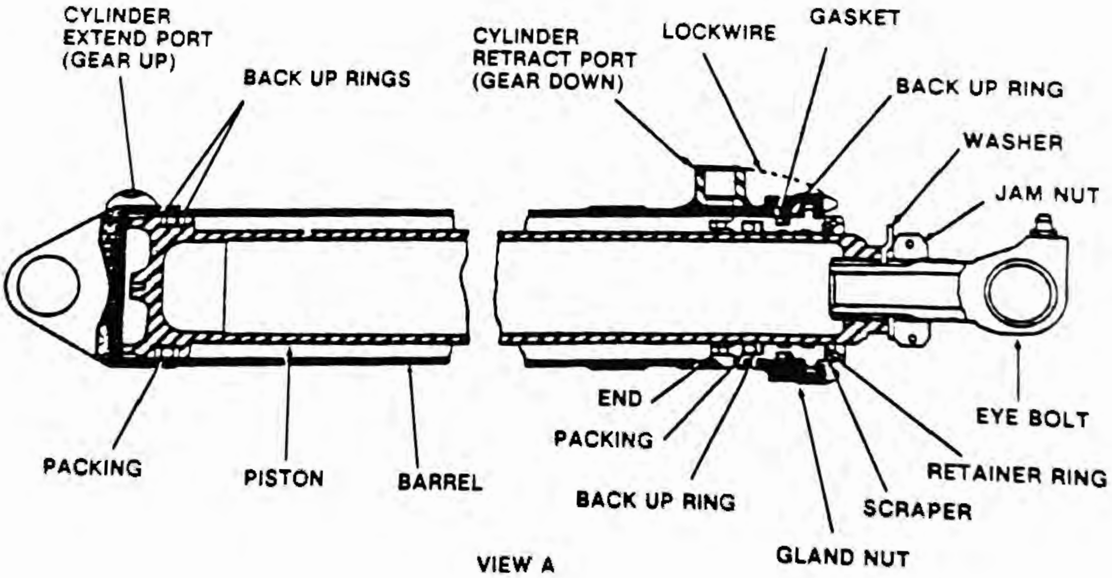
N. Nose Gear Bungee Cylinder (See Figure 32-40)

(1) The nose gear bungee cylinder is a 1-way hydraulic cylinder which is spring loaded to the extended position, and hydraulically actuated to the compressed position. The cylinder consists of a cylinder body, a barrel, a lock spring, and a piston. The barrel is threaded into the body and forms a casing and seat for the spring. The other end of the spring seats on a disc, which seats on the inner end of the piston rod.

(2) During landing gear retraction, hydraulic pressure is ported from the nose gear control valve to the unlock port of the bungee cylinder, overcoming the spring tension and retracting the downlock links from overcenter position.

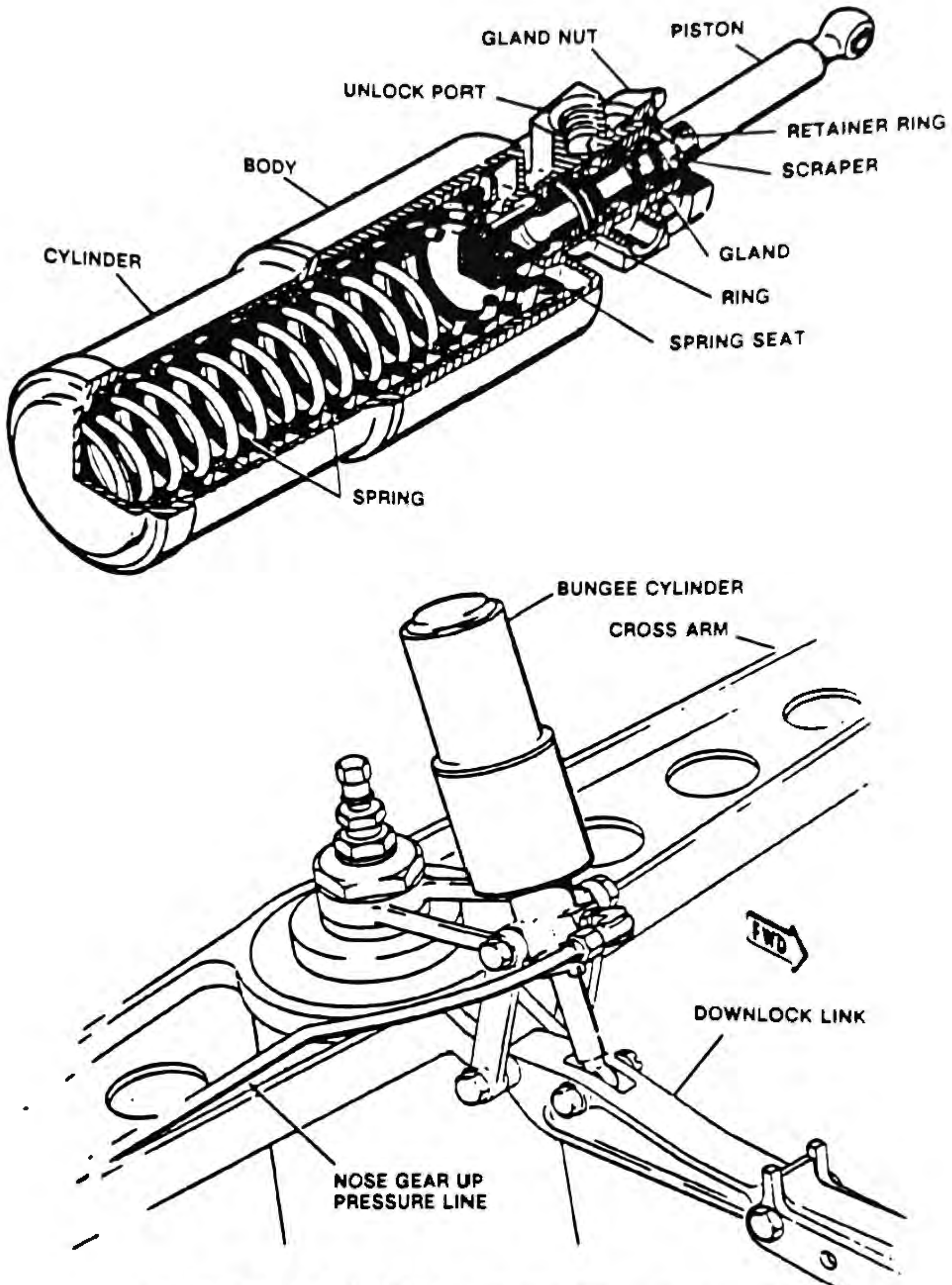
(3) During gear extension cycle, the fluid in the bungee cylinder is ported to return through the nose gear control valve. When the gear is extended, spring tension on the piston rod pushes the downlock links overcenter and locks the nose gear down. The spring tension holds the downlock links in the locked position.





NOSE GEAR ACTUATING CYLINDER -- CUTAWAY FTX80138

Figure 32-39



NOSE GEAR BUNGEE CYLINDER -- CUTAWAY FTX80139

Figure 32-40

O. Nose Gear Uplatch Cylinder (See Figure 32-41)

(1) The nose gear uplatch cylinder is a 2-way, hydraulic actuating cylinder used to overcome the spring tension holding the latch overcenter and to unlatch the nose gear. The cylinder also provides the force necessary to shear out the latch shear pin if the uplatch should jam.

(2) During nose gear retraction, hydraulic pressure is ported to the retract port, retracting the piston into the cylinder. This allows the latch links to be mechanically pulled into the overcenter position without interference by the piston rod. During the extension cycle, hydraulic pressure is ported to the extend port, which applies enough force to overcome spring tension and position the latch links overcenter, allowing the gear to extend.

P. Nose Gear Swivel Gland (See Figure 32-42)

(1) The nose gear swivel gland is a flexible joint for the hydraulic lines routed to the nosewheel steering cylinders and downlock bungee cylinder. The gland body is located on the crossarm and allows free movement of the hydraulic lines when the gear is cycled. The gland shaft is prevented from rotating by a torque arm attached to the wheel well structure.

(2) The swivel gland consists of a body, shaft, and a torque arm. The shaft and torque arm are held stationary, and the body rotates with the crossarm and gear strut.

(3) The small hydraulic line from the nose gear control valve attaches to the small port on the block end of the shaft. The nosewheel steering lines attach to the two large ports on the shaft. The two large lines form the bottom of the body are routed to the steering cylinders and are clamped to the side braces. The small port line goes to the bungee cylinder.

Q. Operation

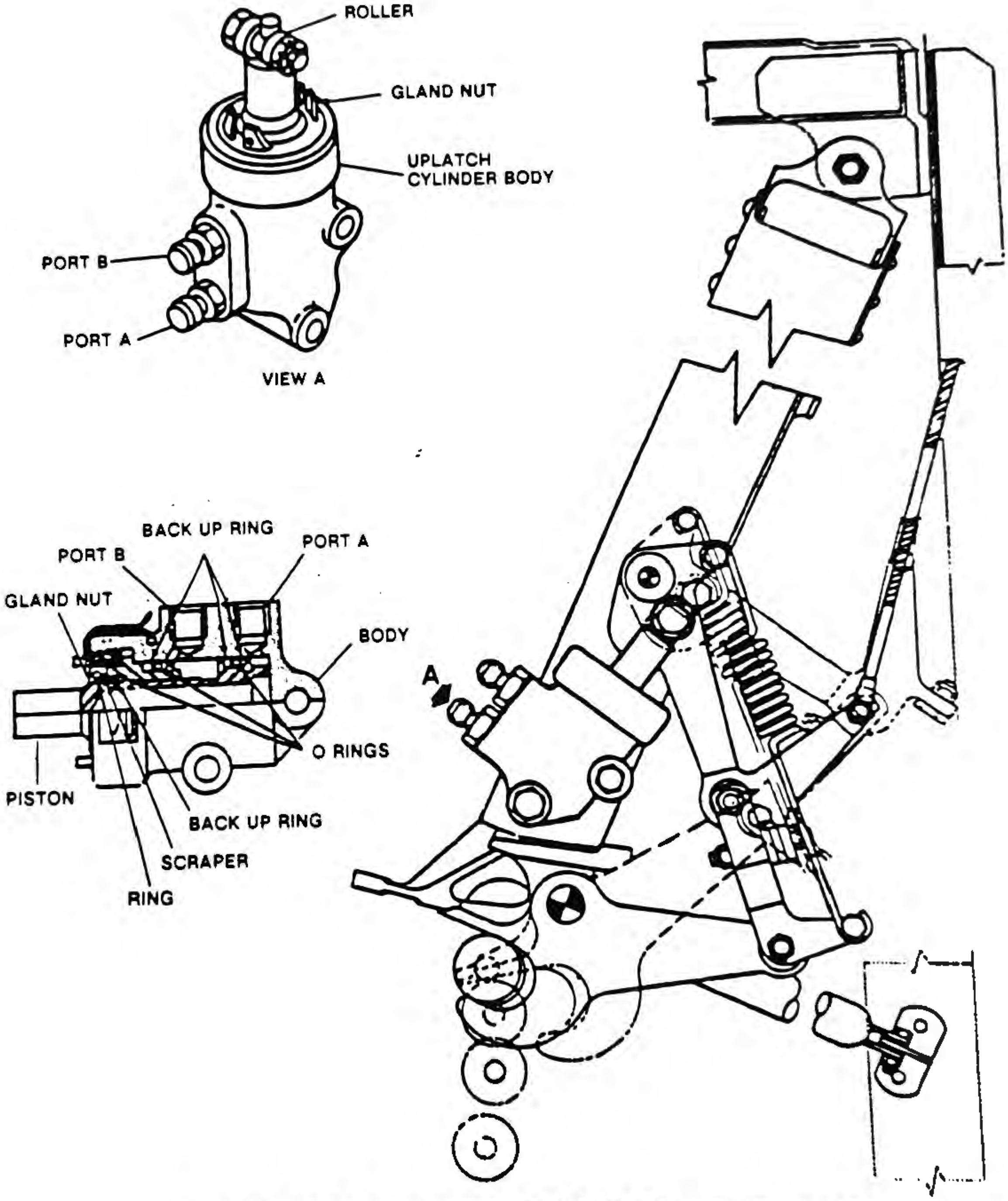
(1) When the landing gear control lever is placed in the gear up position, hydraulic fluid from the nose gear control valve is ported to the nose gear bungee cylinder and the nose gear actuating cylinder. The bun-

gee cylinder unlocks the downlock links and the gear retracts. When the gear reaches the up position, the drag link knee bolt engages the uplatch mechanism and locks the gear up.

(2) Simultaneously, hydraulic fluid is ported from the main gear control valve to the main gear bungee cylinders and main gear actuating cylinders. The bungee cylinders unlock the downlock links and the actuating cylinders retract the gear. During the first few degrees of gear travel, the door followup mechanism will position the inboard door control valves to port pressure to the main gear door actuating cylinders and open the doors. When the gear is within the last few degrees of travel, the door followup mechanism will position the valves to close the inboard doors. The doors and gear will then actuate their respective uplatch mechanisms. After the gear is up and latched, the landing gear control lever is moved to the uplatch check position. This allows the gear to rest on the uplatches and confirms gear latch engagement. After the uplatch check is made, the landing gear control lever is returned to the gear up position, which hydraulically holds the gear off the latches.

(3) To extend the gear, the landing gear control lever is placed in the gear down position. The cable systems position the nose and main gear control valves to port hydraulic pressure to the downlines of each system as follows: The nose gear control valve ports pressure to the nose gear uplatch cylinder, disengaging the uplatch mechanism and to the nose gear actuating cylinder to extend the gear. When the gear is fully extended, the bungee cylinder locks the downlock links overcenter. Simultaneously, the main gear control valve ports hydraulic pressure to both main gear uplatch cylinders and door uplatch cylinders, actuating the latch mechanisms and releasing the gear and doors. Pressure from the main gear actuating cylinders passes through restrictors to slow the gear actuation. This allows the gear to practically free-fall. The main gear inboard door followup mechanism during the first few degrees of gear travel, will open the main gear inboard doors and will close them when the gear nears the extended position. The downlock bungee and the bungee springs actuate the downlock links overcenter to lock the gear down.

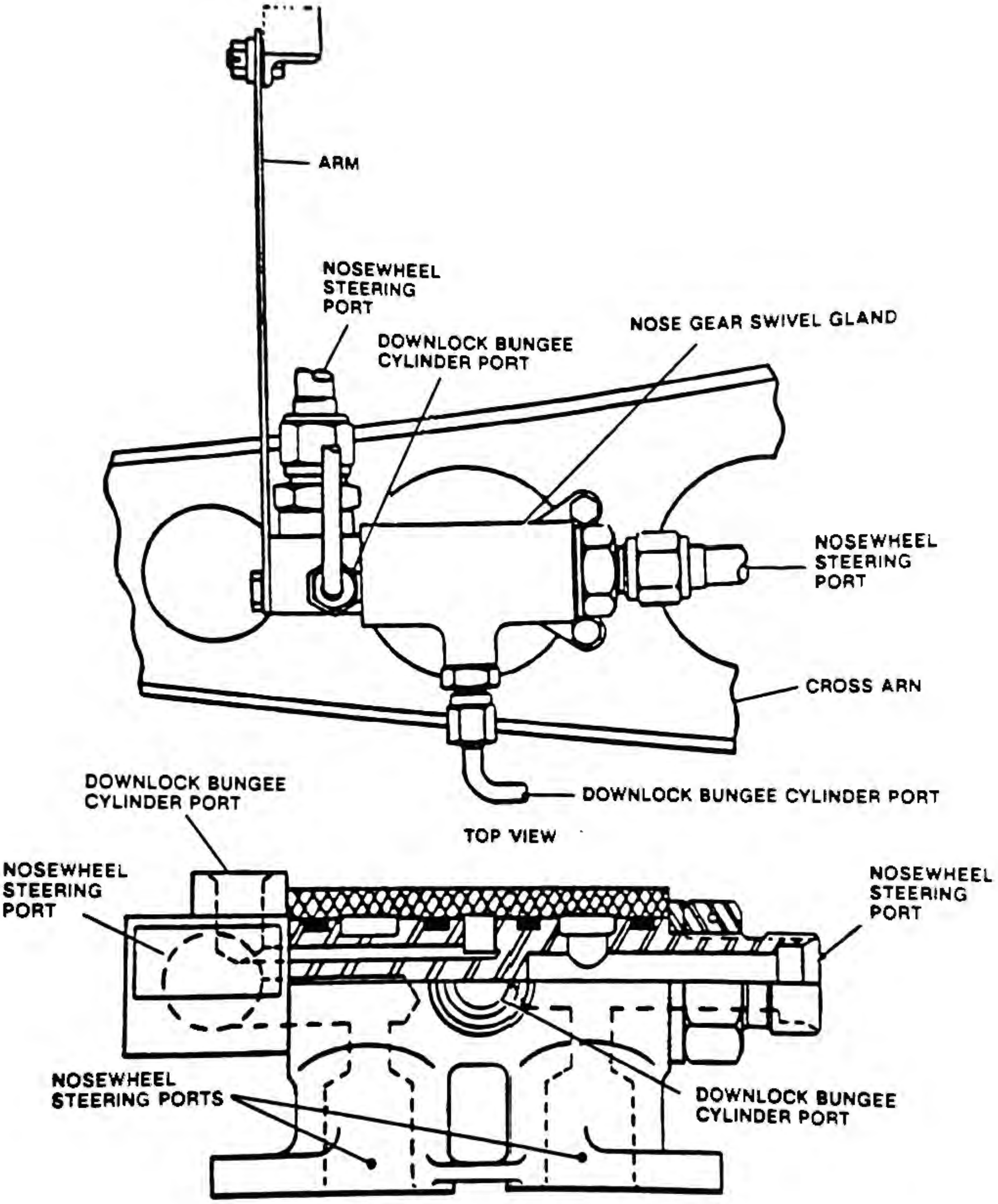
(4) In case of hydraulic power failure, the nose and main gear can be extended by placing the landing gear control lever in the gear down position. The cable systems will mechanically release the uplatches and allow the gear to free-fall.



NOSE GEAR UPLATCH CYLINDER -- CUTAWAY

FTX80140

Figure 32-41



NOSE GEAR SWIVEL GLAND -- CUTAWAY

FTX80142

Figure 32-42

7. Bogie Trim Cylinder - Description and Operation

A. General (See Figures 32-43, 32-44 & 32-45)

(1) The bogie trim cylinder is a double-acting hydraulic cylinder that keeps the bogie beam and wheels in a position perpendicular to the main gear struts during gear retraction and extension, and dampens the oscillation action of the bogie beam during taxiing and braking.

(2) The bogie trim cylinder is mounted on the forward side of each main gear strut. The cylinder head is attached to the bogie beam through a universal joint fitting, and the rod end is attached to the shock strut through a universal joint fitting. These attachments are made through universal joints to relieve side loads on the trim cylinders.

(3) The bogie trim cylinders are supplied hydraulic pressure directly from the main hydraulic system line downstream of the priority valve. A relief valve is installed between the trim cylinder pressure inlet line and return line to relieve excessive pressure in the cylinder and lines that may build up due to any violent action of the bogie beam.

(4) Each trim cylinder consists of a body, a hollow piston and rod assembly, a floating piston, gland nut, scraper, seals, and O-rings. The body incorporates two ports and supports the head end and stop assembly and piston rod gland. The head end and stop assembly incorporates a hollow shaft on which the floating piston rides and the stop nut is threaded. The head end and stop assembly is vented overboard to prevent an airlock between the floating piston and the hollow piston.

(5) Both ends of the cylinder are supplied hydraulic pressure from a common supply line through orifice valves located in the T-fitting. The floating piston has a greater displacement than the piston rod end: due to its construction, it always seeks a neutral position.

B. Operation

(1) During takeoff, if the cylinder has been compressed, the floating piston is unseated from the stop by the hollow piston and rod action. Due to the greater displacement of the floating piston, the piston assemblies are moved back toward the internal stop when the weight of the airplane has been moved from the main gear wheels. When the

floating piston contacts the internal stop, the hollow piston is hydraulically held in neutral position. At this time, the bogie beams are held perpendicular to the shock strut. Any attempt at porpoising by the bogie beams forces fluid from one end of the trim cylinder to the other end. The orifice valves in the pressure inlet line T-fitting and the difference in displacement causes a snubbing action which dampens bogie beam movement. If a violent action does occur that builds up an excessive pressure, the bogie trim cylinder relief valve will relieve the pressure and prevent structural damage to the cylinder or the hydraulic lines.

8. Wheels and Brakes - Description and Operation

A. General

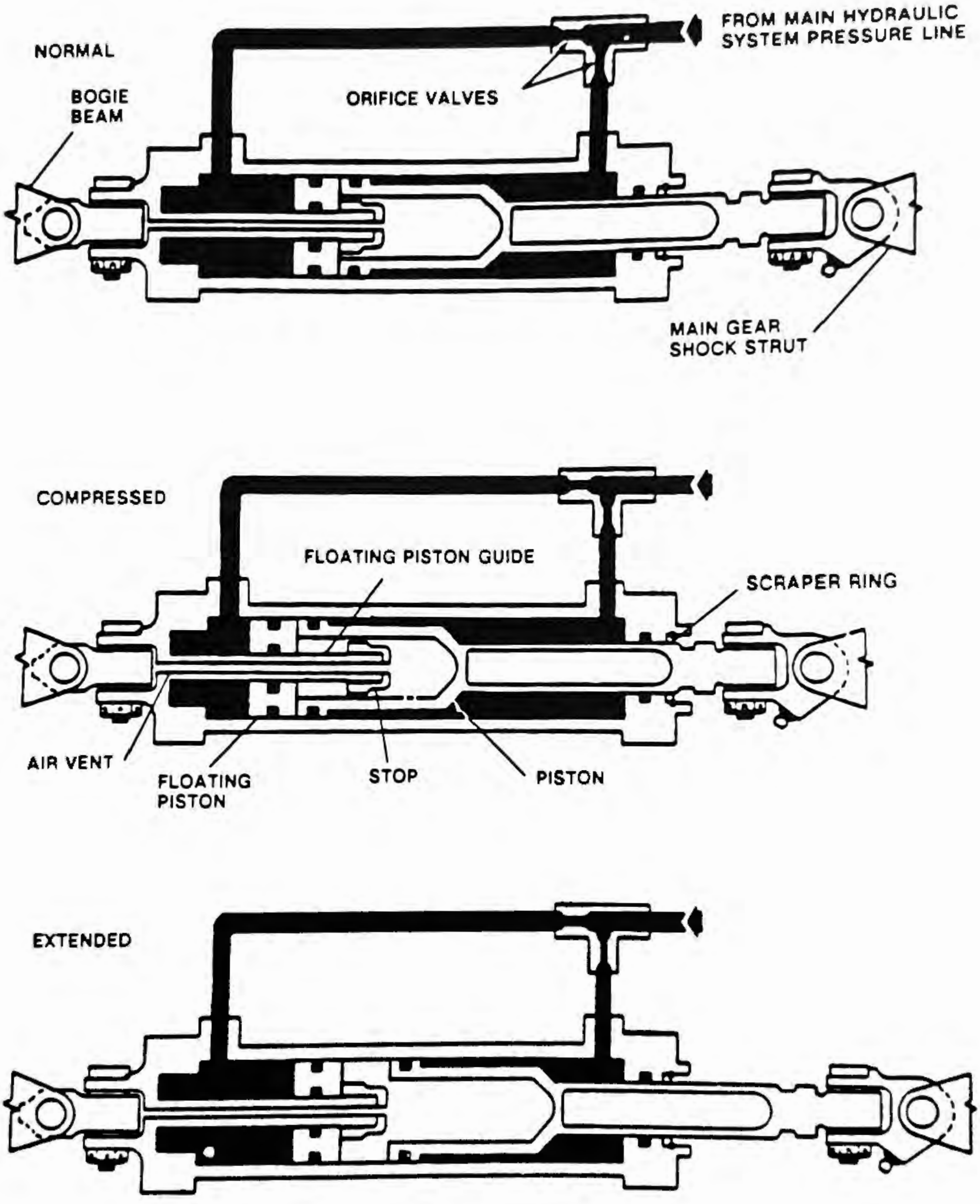
(1) The airplane is equipped with two nose gear wheels mounted on a single axle, and eight main gear wheels, four mounted on each bogie. Each main gear wheel is fitted with a multi-disc, hydraulically actuated brake.

(2) Each main gear is fitted with four 44x16, type-VII, split-type, forged aluminum wheels. The nose gear is fitted with two, 34x11, type-VII, split-type, forged aluminum wheels. All wheels are made airtight for use with tubeless tires by an O-ring seal, installed in a groove between the wheel halves. The main gear wheels have four equally spaced heat fuses installed in the inner wheel half to protect the tires against excessive heat blowouts.

(3) Each main gear wheel is fitted with a multi-disc, hydraulically actuated brake. Each brake is actuated by seven hydraulic pistons, and is returned to normal configuration by seven retract springs.

(4) The brakes are controlled by a mechanical control system composed of a cable system, brake pedals, and a control valve. A separate manually controlled cable system actuated a pneumatic system which can be used as a backup system when normal hydraulic power is not available.

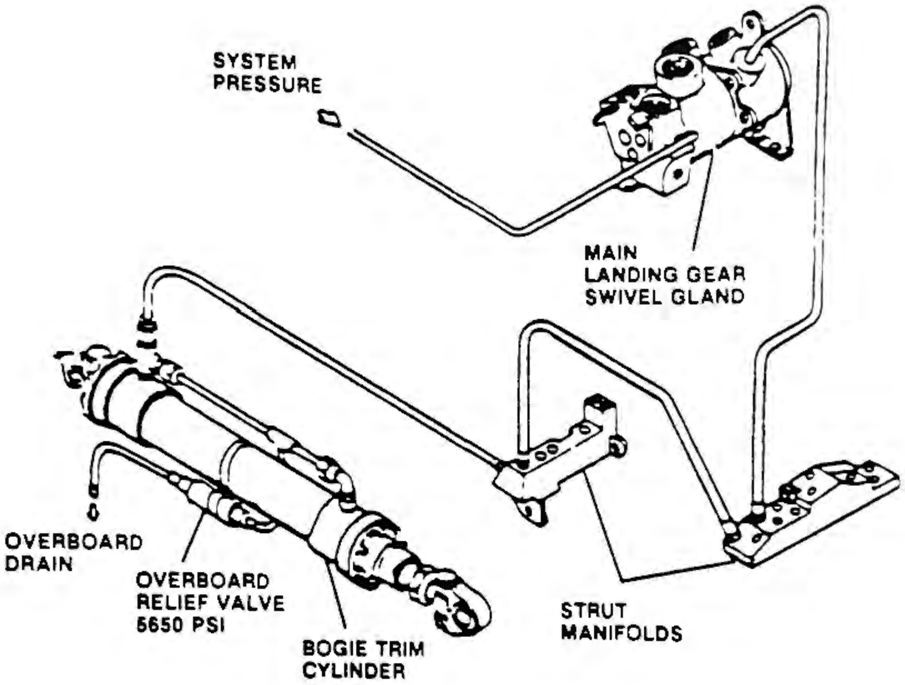
(5) The power brake system is supplemented by an electrically controlled anti-skid system to obtain a more effective braking application, through control of wheel torque at the point of maximum braking efficiency.



BOGIE TRIM CYLINDER -- SCHEMATIC

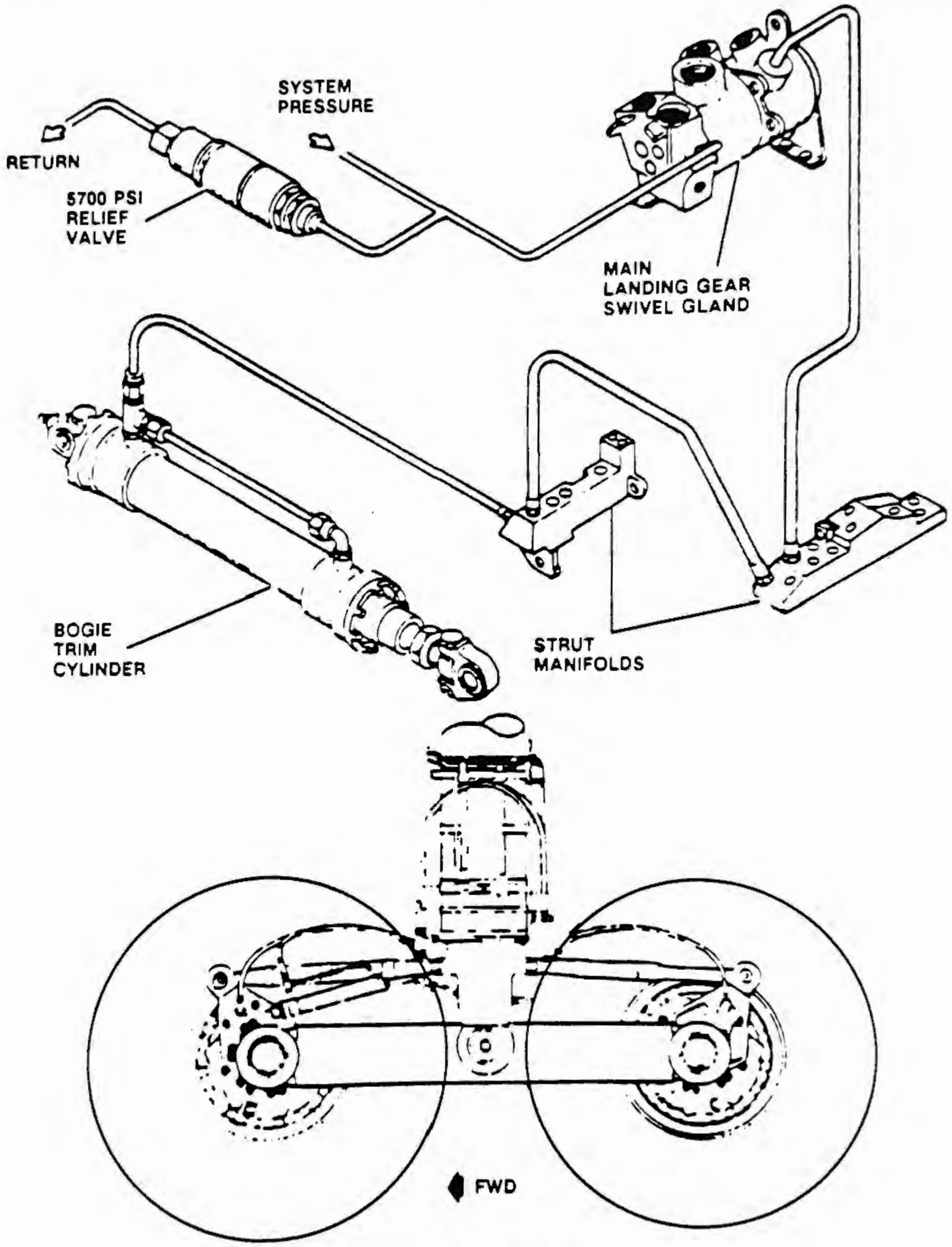
FTX80143

Figure 32-43



BOGIE TRIM CYLINDER FTX80144

Figure 32-44



MAIN LANDING GEAR BOGIE TRIM SYSTEM FTX80145

Figure 32-45

B. Main Gear Wheel and Tire Assemblies (See Figure 32-46)

(1) The main gear wheels are Bendix 44x16, type VII. The wheels are split to facilitate tire removal and mounting. Both wheel halves are machined from forged aluminum. The split between the wheel halves is sealed by an O-ring to make the wheels airtight for use with tubeless tires. The tires are 44x16, type-VII, nylon fabric tubeless tires.

(2) A standard tapered wheel bearing is installed in each wheel half. Adjustment of the bearings is controlled by the axle nut. The inner bearings are protected against loss of lubricant and the entrance of dirt by moisture-resistant, silicone-impregnated felt seals which wipe on aluminum wipers. The seal is mounted on the axle between the bearing spacer and the bearing cone.

(3) The wheel and tire assemblies are protected from heat generated by the brakes by a stainless steel heat shield. As a further protection against tire blowouts resulting from excessive heat, four fuse screws are equally spaced around the wheel inner half. Each fuse screw contains a spherical, preformed, packing held in place by a fusible washer made of a controlled melting point alloy. Before the air in the tire becomes hot enough to cause a tire blowout, the fusible washer will melt and allow the packing to blow out, permitting the air to escape from the tire. The fuse melting point is 350°F (176.6°C) maximum (color coded blue).

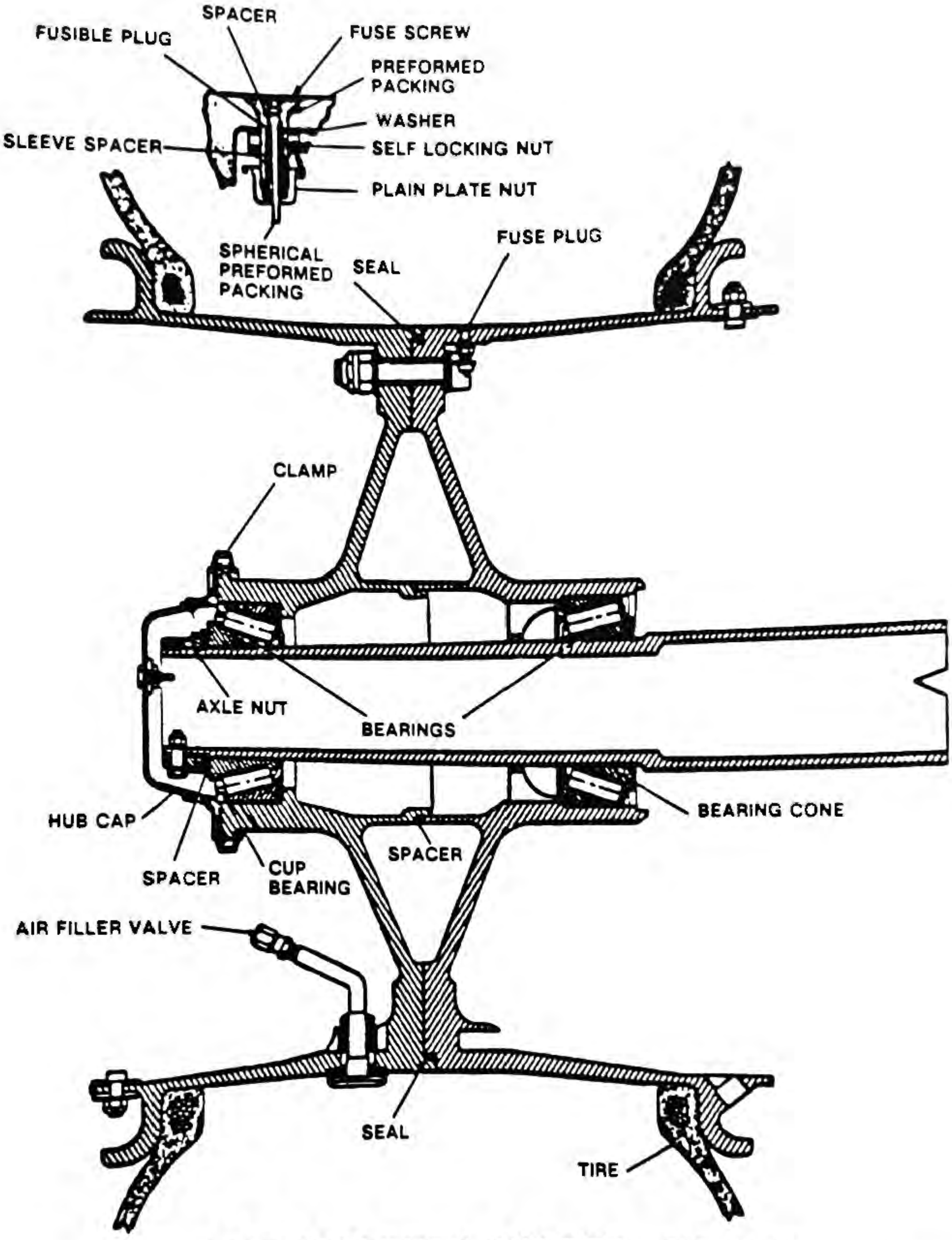
C. Nose Gear Wheel and Tire Assemblies (See Figure 32-47)

(1) The nose gear wheels are Goodyear 34x11, type VII, designed for use with either a tubeless tire or a tire and tube. The wheel is the divided type with the wheel halves joined by eight high-tension bolts and nuts. An air seal is provided between the wheel halves by an O-ring which is retained in a groove in the inner wheel half. Each wheel half has a standard, tapered roller bearing. The bearings are protected against loss of lubricant and the entrance of dirt by moisture-resistant, felt seals, which rub on the wheel spacers. Adjustment of the bearings is controlled by the axle nut. The nose gear wheels carry 34x14, type-VII tires.

D. Main Gear Wheel Brakes

(1) The main gear wheel brakes are a multi-disc type, hydraulic power brake consisting of seven rotating and eight stationary frictional elements. The rotating elements (rotors) are keyed into the wheel assembly and are segmented to reduce warpage. The stationary elements are integral with the brake assembly and are fitted with replaceable linings.

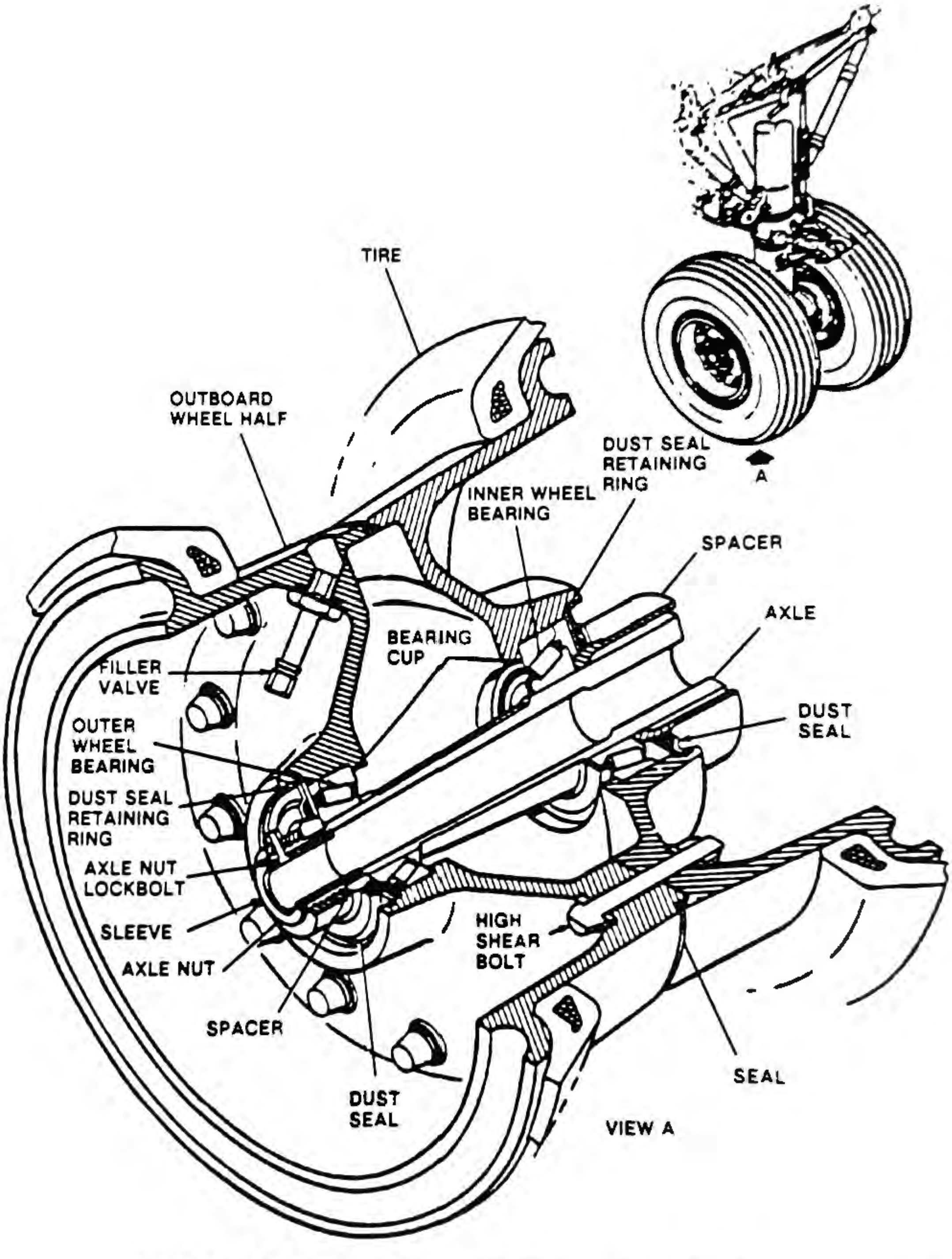
(2) The brake carrier consists of a carrier and a backing plate. The carrier houses seven retract spring assemblies, three clearance adjustment screws, seven hydraulic actuating pistons, two bleed ports, an inlet port, and interconnecting fluid passageways.



MAIN GEAR WHEEL AND TIRE -- CUTAWAY

FTX80147

Figure 32-46



NOSE GEAR WHEEL AND TIRE -- CUTAWAY FTX80148

Figure 32-47

9. Wheel Brake Mechanical Control System - Description and Operation

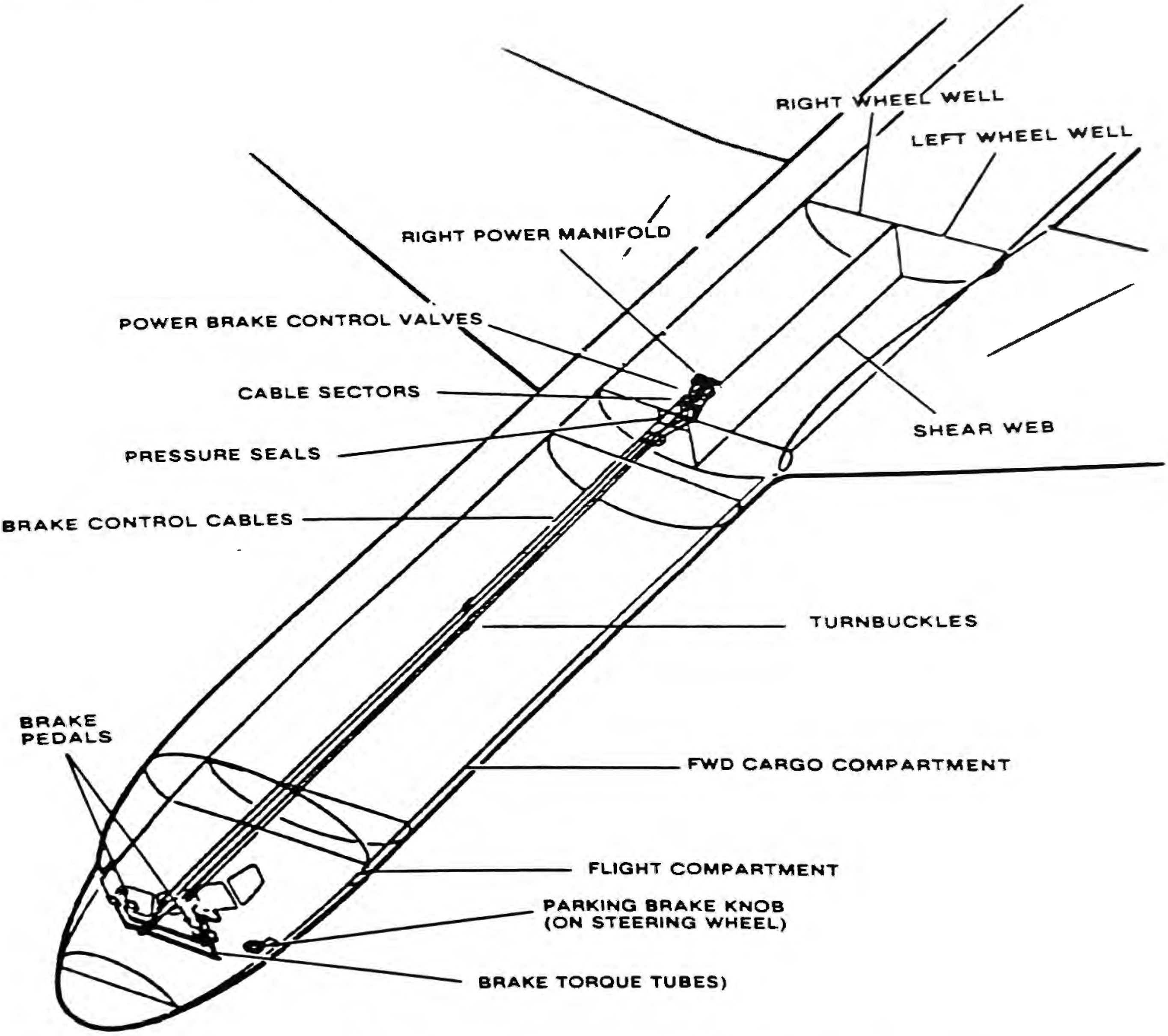
A. General (See Figure 32-48)

(1) The wheel brake mechanical control system consists of two, two-way closed circuit, cable runs which extend from the brake torque tubes in the flight compartment to the brake control valves in the right main gear wheel well. Each brake pedal controls a cable system which operates a corresponding brake control valve. The brake pedals are bussed together by the brake torque tubes to afford coordinated actuation of the brake control valves and the brakes by the captain and/or the first officer. One cable drum is installed on each torque tube. The brake pedals actuate the cable drums, which drive the brake control valves through cables and linkages.

(2) The parking brake mechanism is a mechanical means of holding the wheel brake control valves in a set position. It consists of a knob and latching mechanism interconnected by a cable.

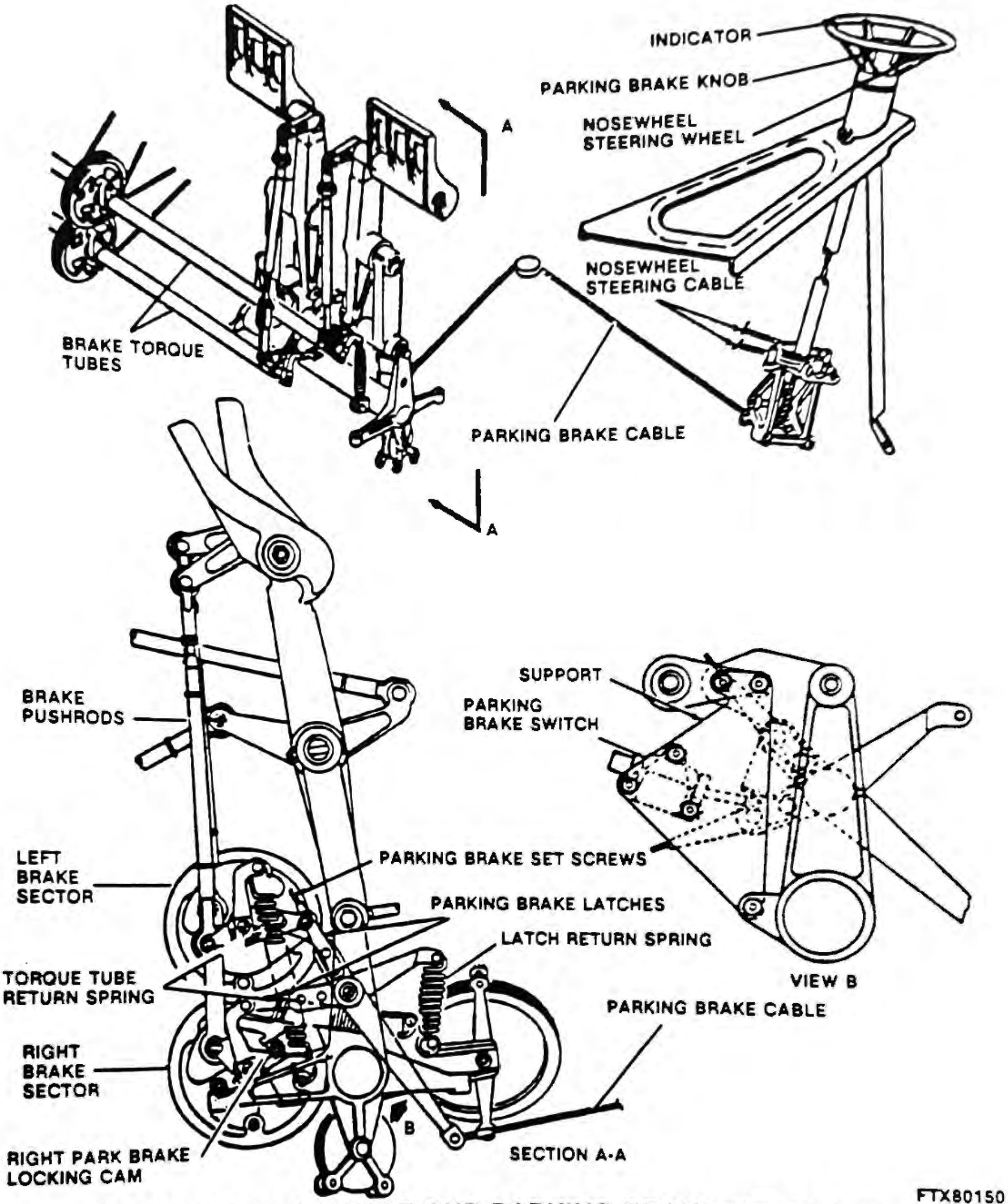
B. Brake Pedal Linkage (See Figure 32-49)

(1) The main gear wheel brake system is mechanically actuated by the brake pedals. The rudder pedals are primarily used to operate the rudder controls, but, when pivoted at the upper end to drive the brake control linkage, they are referred to as brake pedals. The small cranks, one located on each pedal, extend forward to serve as pushrod connections. The pushrods extend down and connect to the brake torque tubes. The two torque tubes connect the captain's brake pedals to the first officer's brake pedals and support the two cable drums which drive the brake cable systems. A crank, attached to the left outboard end of each torque tube, is one attach point for the brake pedal return spring; the other end of the spring is attached to the rudder pedal support bracket. The outboard end of the torque tube also supports linkage which connects to the pedal steering override mechanism. A parking brake latch, latch return spring, and locking cam assembly are installed on the end of each brake torque tube between the two left pedal support brackets.



WHEEL BRAKE MECHANICAL CONTROL SYSTEM FTX80149

Figure 32-48



BRAKE PEDAL LINKAGE AND PARKING BRAKE MECHANISM

Figure 32-49

C. Parking Brake Mechanism

(1) The parking brake mechanism is a mechanical means of holding the wheel brake control valves in the pressure applied position. The mechanism consists of a knob and latching assembly interconnected by a single cable.

(2) The knob assembly is installed in the hub of the nosewheel steering wheel and consists of a 2-piece, pressure sealed knob and cap attached to a slotted sleeve. A cable extends from the knob assembly, through the steering shaft, around a guide pulley, and to the parking brake latch assembly.

(3) The parking brake latch assembly is mounted between the two left rudder pedal support brackets. The hub assembly consists of a casing containing two bearings and a spacer, an operating crank to which the cable from the knob is attached, a lever to which the return spring is attached, and two arms on which the latching pawls are installed. The hub assembly is attached to the rudder pedal support brackets by a bolt. The notched locking cams are an integral part of the left end of the brake torque tubes.

(4) The parking brake switch is mounted on a bracket adjacent to the hub assembly and is actuated by a striker on the hub. When actuated, the switch opens an electrical circuit to the antiskid system dual servo valves to assure deactivation of the locked-wheel protection condition in the servo valves.

D. Operation

(1) The wheel brake mechanical control system is actuated by the brake pedals. By depressing the pedals at their upper pivot axis, the pedals actuate linkage which operates the cable sectors on the torque tubes. The cable sectors drive the cables, which extend through the fuselage to the cable sectors and linkages in the right main gear wheel well, which in turn operate the hydraulic brake control valves. The control valves port hydraulic pressure to the main gear wheel brakes.

(2) To set the parking brakes, the brake pedals are depressed, and the knob on the steering wheel is lifted. The knob actuates a cable which engages the two latching pawls with the two cam notches on the ends of the torque tubes. This holds the brake pedals in the depressed

position, and, at the same time, actuates the parking brake switch. The parking brakes are released by depressing the pedals to release the latches from the cam notches. The stops are spring loaded and release the latches from the cams.

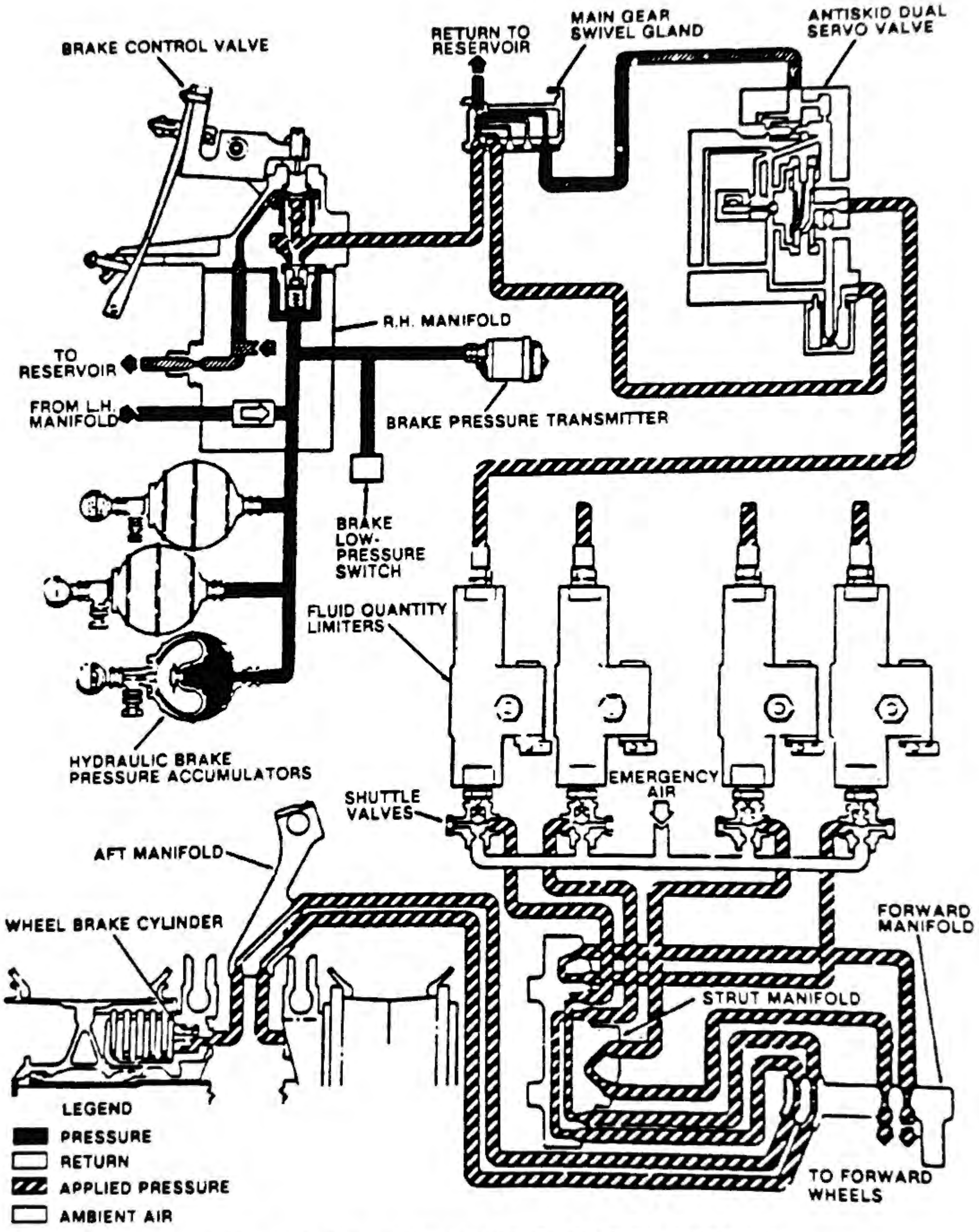
10. Wheel Brake Hydraulic Control System - Description and Operation

A. General (See Figure 32-50)

(1) The wheel brake hydraulic control system consists of the main gear wheel brakes, power brake control valves, antiskid dual servo valves, hydraulic pressure accumulators, hydraulic fluid quantity limiter and shuttle valve, hydraulic pressure transmitter and indicator. The wheel brake hydraulic system is supplemented by a pneumatic backup system which may be used if the main hydraulic system pressure is lost.

(2) The antiskid system is an elective part of the brake system, which provides locked-wheel protection, skid protection, and corrective action. When the antiskid system is not armed, the brakes are operated manually. All hydraulic pressure to the brakes is metered through the brake control valves and servo valves by application of the brake pedals, except during gear retraction cycle when the brake control valve is automatically actuated by restricted return pressure from the gear downline to stop wheel rotation in the wheel wells.

(3) The brake pressure accumulators provide hydraulic pressure for several brake applications without replenishment from the main hydraulic power system. The accumulator reserve pressure is used to hold the brakes in the parked position.



WHEEL BRAKE HYDRAULIC CONTROL SYSTEM

FTX80151

Figure 32-50

B. Main Gear Wheel Brakes (See Figure 32-51)

(1) The main gear wheel brakes are multi-disc, hydraulic power brakes consisting of seven rotating and eight stationary elements. The rotating elements (rotors) are keyed into the wheel and are segmented to reduce warpage. The stationary elements are keyed to the brake torque tube and are fitted with replaceable linings.

(2) The brake carrier assembly consists of a carrier and a backing plate. The carrier houses seven retract spring assemblies, three clearance alignment adjustment screws, seven hydraulic piston assemblies, two bleed ports, a fluid inlet port, and interconnecting fluid passageways. The backing plate is attached to the carrier, and the shaft of the backing plate is splined and serves as the index and support for the stators and the pressure plate. There are seven brake linings riveted to the inner face of the backing plate. The backing plate absorbs and transfers the brake torque to the carrier. The area between the inner face of the backing plate and the carrier houses the stators, rotors, and the pressure plate.

(3) The pressure plates, stator plates and torque tubes have a full circular flange, and each has seven trapezoid-shaped brake linings riveted to it. The pressure plate applies pressure from the pistons to the rotors and stators. After hydraulic pressure is relieved, the pressure plate is returned to free running position by the return spring assemblies. The inner circumference of the pressure plate is slotted to index with the splines on the torque tube.

(4) The seven retract springs are installed in equally spaced housings which are integral with the carrier. The three adjusting screws are used to maintain the proper clearance and travel of the pressure plate.

(5) The hydraulic piston assemblies are contained in seven equally spaced housings around the carrier, and consist of a cylinder, piston, seals, and a pad. The head of the cylinders are open to internal fluid passageways in the carrier. When hydraulic pressure is applied to the head of the pistons, the seven pads apply a uniform force against the pressure plate.

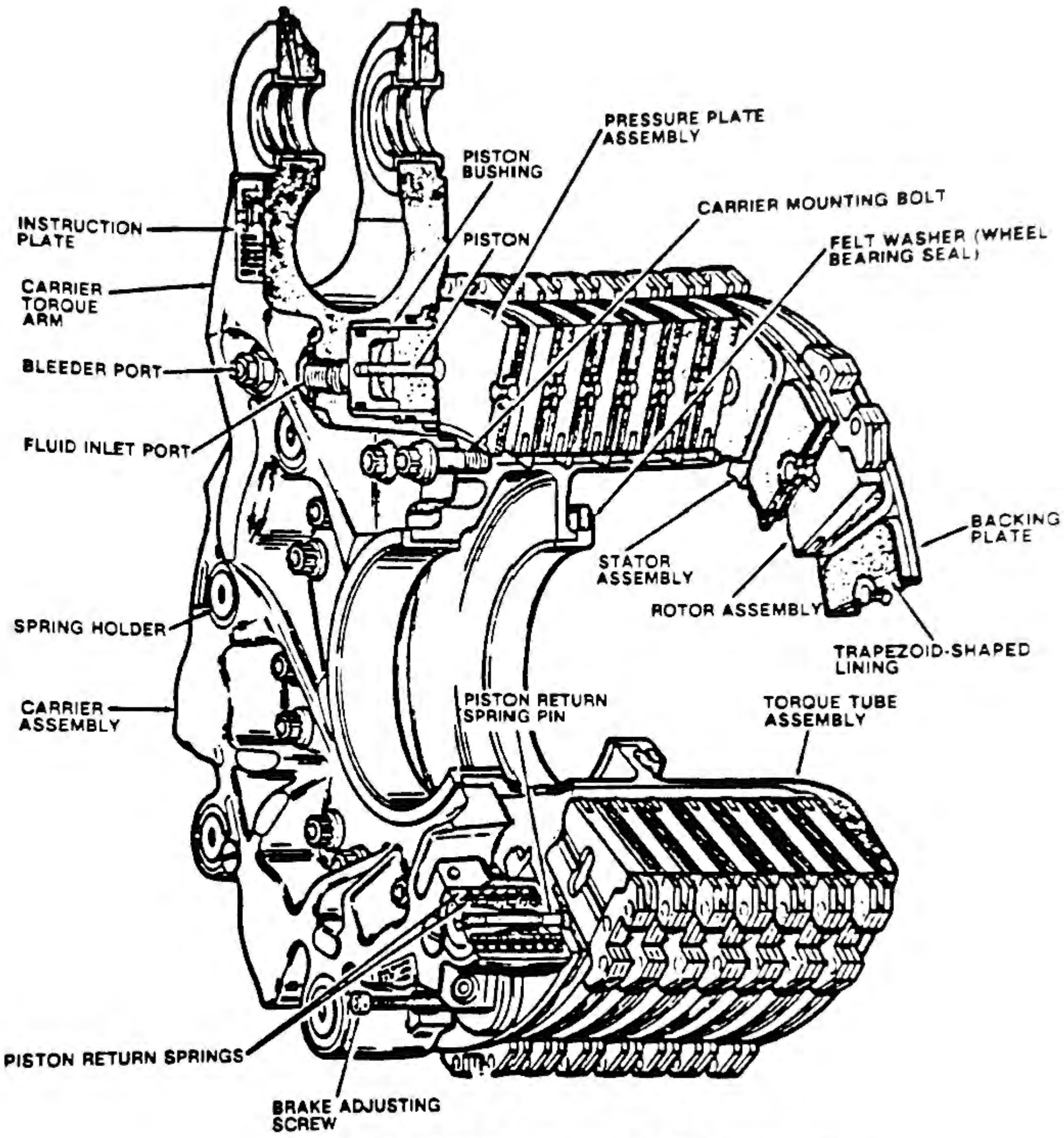
(6) Eight stator plates serve as the intermediate lining-carrying members. Seven linings are mounted back-to-back on each plate by two rivets. Brake torque is transmitted from the stator plates to the torque tube by several slots at the inside circumference of the plate. The slots are indexed to mate with torque tube splines.

(7) Each of the seven rotors consists of eight segments mounted on a steel spider. The outward radial movement of the segments, induced by high-rotational speed, is restricted by steel straps riveted to the ends of the spider arm. Eight keyways are located around the circumference of each rotor and engage eight keys installed around the inner rim of the wheel.

C. Wheel Brake Control Valves (See Figure 32-52)

(1) The wheel brake control valve is a dual, mechanically actuated valve used to meter hydraulic pressure to the dual servo valves and the main gear wheel brakes. Externally, the valve consists of a valve body, two valve lever assemblies, two adjustable lever stops, and a slide and poppet assembly.

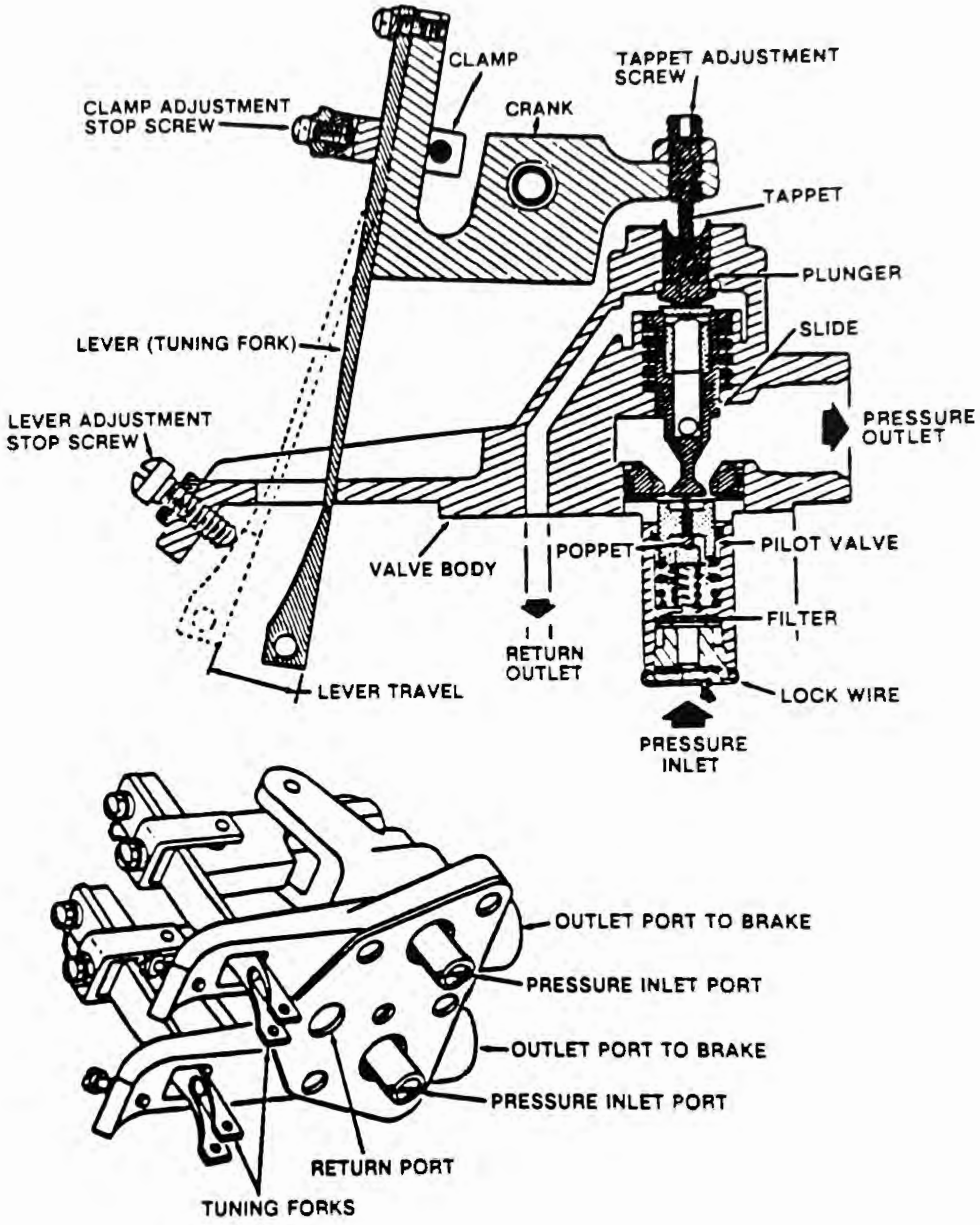
(2) The brake control valve consists of two complete assemblies installed in the valve body. Each valve consists of a plunger, return poppet, lapped sleeve and slide assembly, inlet poppet and pilot valve, and an inlet filter.



MAIN GEAR WHEEL BRAKE CUTAWAY

FTX80152

Figure 32-51



WHEEL BRAKE CONTROL VALVE CUTAWAY

FTX80153

Figure 32-52

D. Hydraulic Fluid Quantity Limiters and Shuttle Valves (See Figures 32-53 & 32-54)

(1) The hydraulic fluid quantity limiter is a device used to close hydraulic lines downstream of the antiskid servo valves if a hydraulic line or hose should rupture or break. One limiter is installed in each brake line near the servo valve outlet port.

(2) This type of limiter is self-resetting, requiring only a pressure equalization of approximately 5-psi to reset. Fluid quantity limiters perform the same basic function as a lockout cylinder, by isolating an open line from the main hydraulic system to prevent loss of hydraulic fluid.

(3) The fluid quantity limiter has a bypass valve mounted on the limiter body. The bypass valve consists of a runaround passageway and shutoff valve, which is used to bypass the metered section of the limiter to allow a fluid free flow during brake bleeding procedures or brake pressure readings at the brakes. A lever on the bypass valve is used to unseat a shutoff poppet and allow free flow around the limiter.

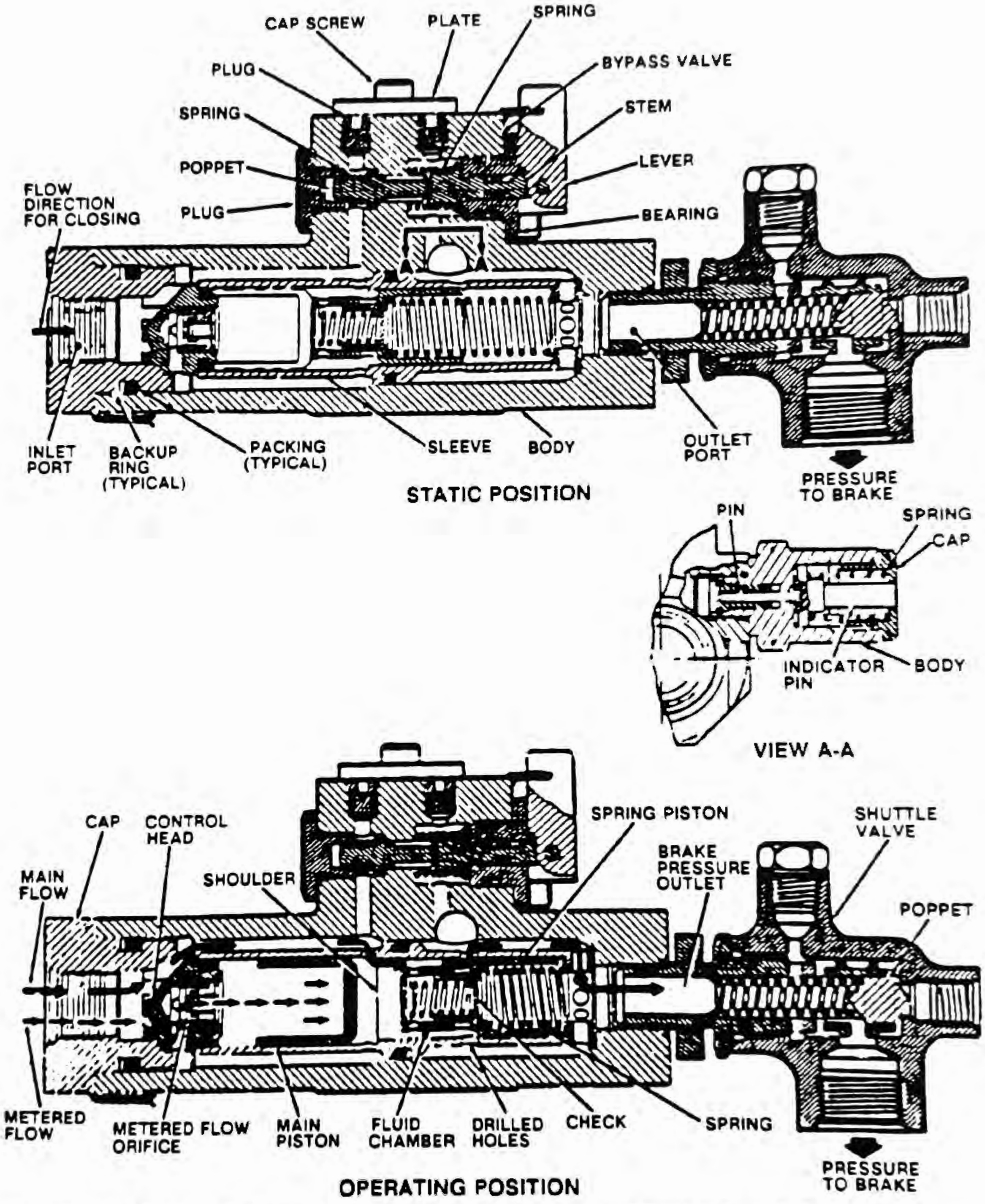
(4) A pressure indicator button is installed on the limiter to provide a visual means of verification that pressure is being supplied to the brakes.

(5) The shuttle valve is located at the downstream end of the fluid quantity limiter, and is used to port hydraulic pressure or emergency air pressure to the brakes. Normally, the air port is blocked.

E. Wheel Brake Pressure Accumulators (See Figure 32-55)

(1) The wheel brake pressure accumulators are spherical, steel fluid and air containers used to provide a reserve supply of hydraulic fluid under pressure for brake application and parking brakes.

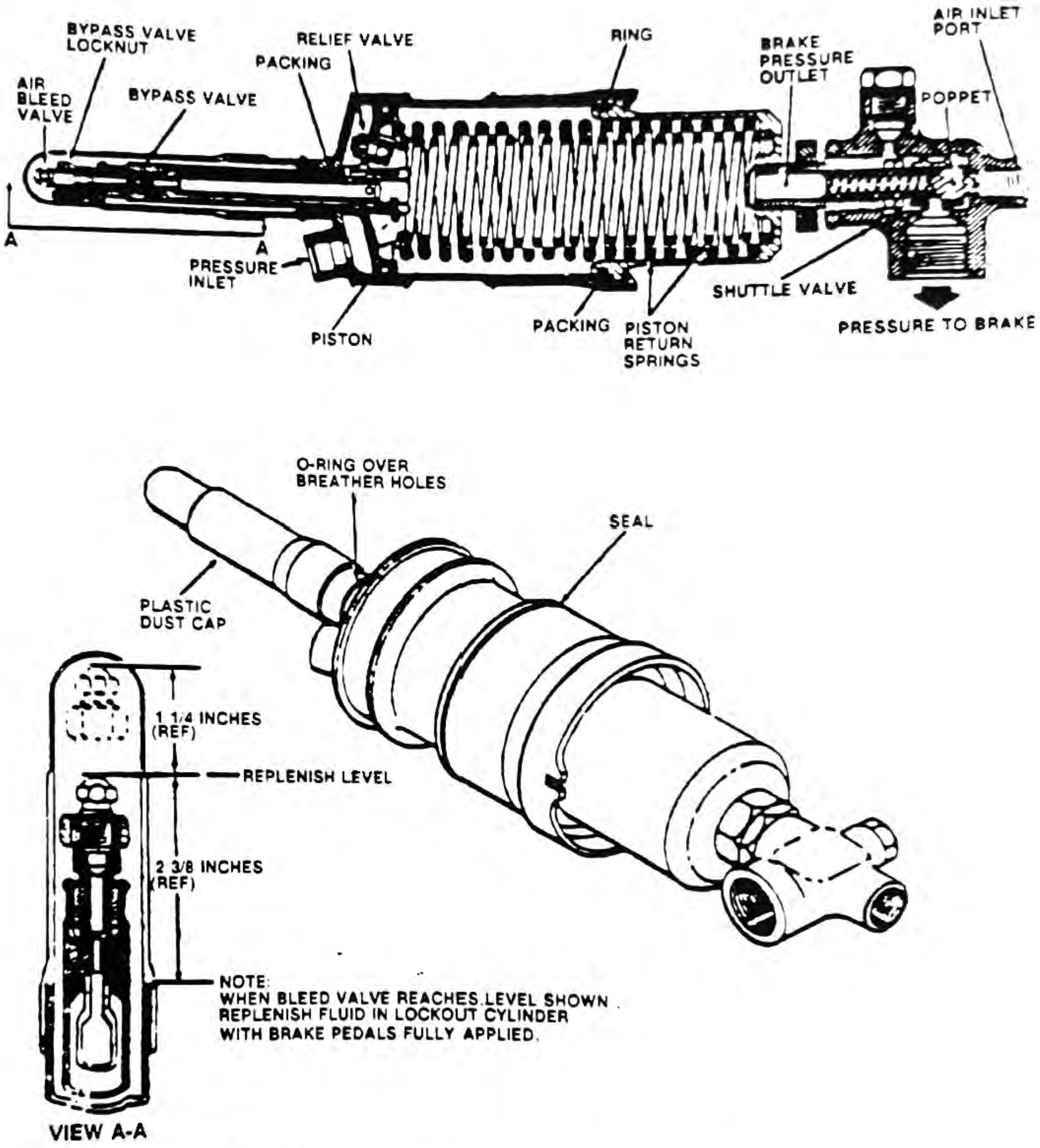
(2) Internally, the accumulator is separated into two sections or chambers by a balloon-shaped bladder. One chamber retains hydraulic fluid under system pressure; the other chamber is charged with dry nitrogen, which acts as a damper to absorb pressure surges in the brake system.



HYDRAULIC FLUID QUANTITY LIMITER AND SHUTTLE VALVE CUTAWAY

FTX80154

Figure 32-53

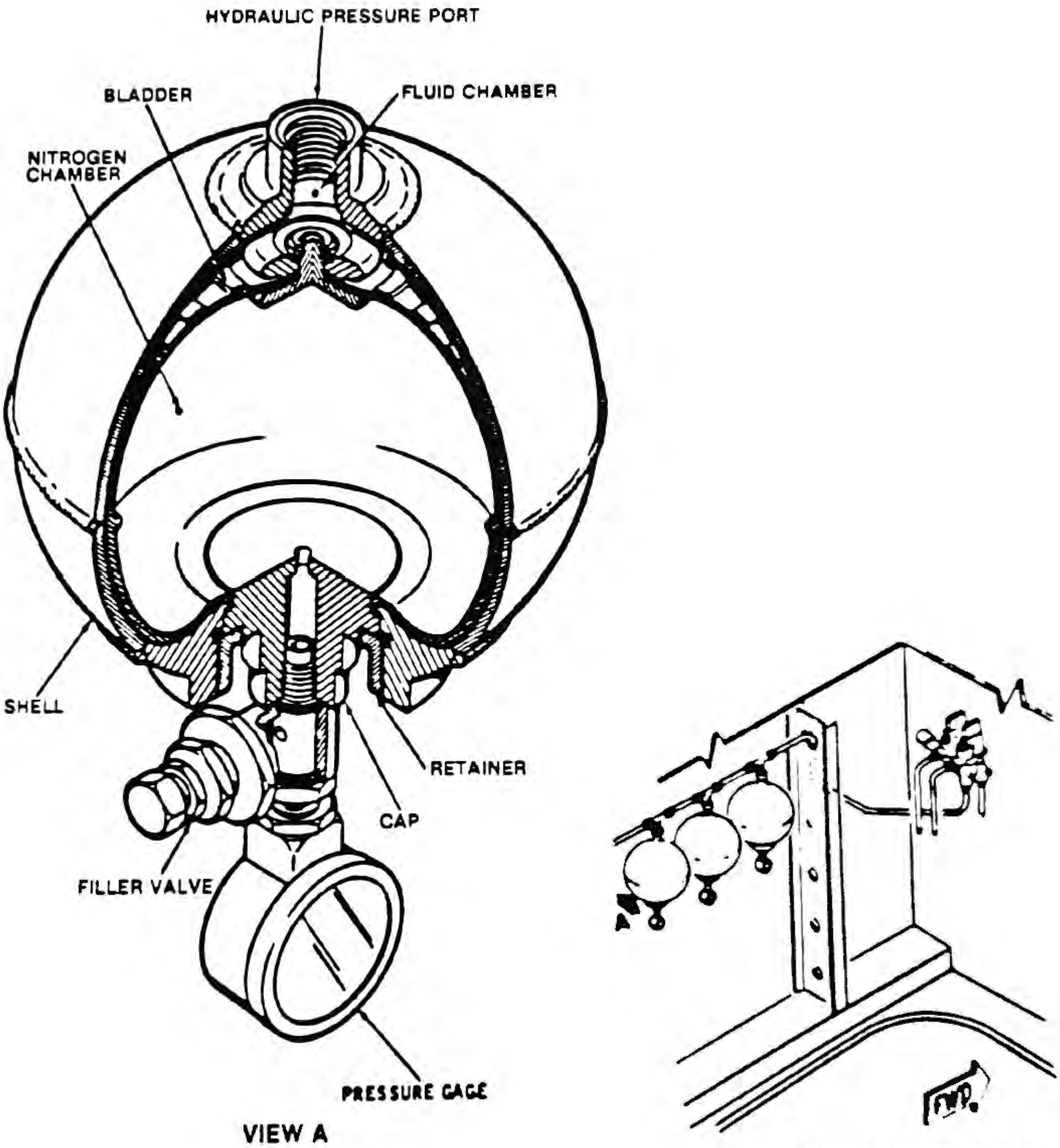


NOTE:
WHEN BLEED VALVE REACHES LEVEL SHOWN
REPLENISH FLUID IN LOCKOUT CYLINDER
WITH BRAKE PEDALS FULLY APPLIED.

WHEEL BRAKE LOCKOUT CYLINDER AND SHUTTLE VALVE

FTX80155

Figure 32-54



VIEW A

RIGHT MAIN GEAR WHEEL WELL

WHEEL BRAKE SYSTEM PRESSURE ACCUMULATOR CUTAWAY

FTX80156

Figure 32-55

F. Brake System Hydraulic Pressure Indicator and Transmitter

(1) The brake system hydraulic pressure is displayed in the flight compartment through use of a synchro-type instrument system consisting of a clamp mounted indicator, and a transmitter which is piped into the brake control valve in the right main gear wheel well. The indicator is identified by markings on the dial face.

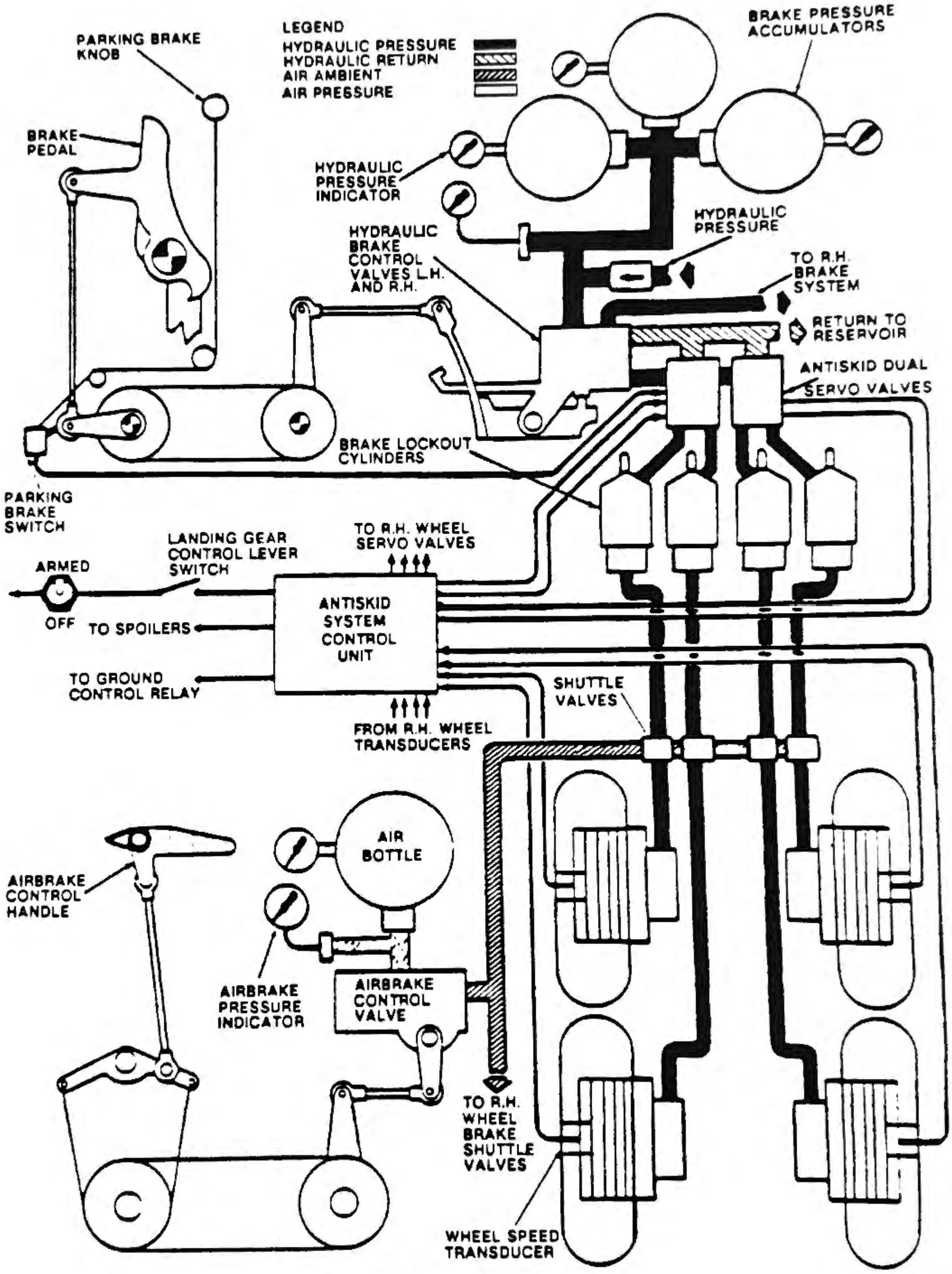
G. Operation

(1) Manual operation of the wheel brake hydraulic control system is accomplished by depressing the upper portion of the rudder pedals, which actuate linkage and cables to the wheel brake control valves. The brake control valves meter hydraulic pressure to the antiskid system dual servo valves, through the fluid quantity limiters, and to the brake cylinders.

(2) When the brakes are applied, metered pressure from the brake control system enters the inlet port of the brake and disperse fluid to the seven brake pistons through drilled passages in the carrier. As the brake pistons move out, they press the pressure plate which in turn presses the stators and rotors together against the backing plate. The compressed disc stack creates friction between the rotating and stationary discs to effect braking action.

(3) The hydraulic fluid quantity limiter functions as shown in Figure 32-53, with hydraulic fluid entering the limiter, and following the paths noted by the arrows. Fluid entering the unit is divided into two flow paths by the control head. The main flow follows the path noted by the heavy arrows. Fluid entering the chamber exerts a force against the spring-loaded piston which permits displacement of the main position.

(4) The main flow passing through the drilled holes produces a slight pressure drop. Since the main piston offers negligible friction resistance because of the hollow buoyant design, the pressure drop across the drilled holes is equal to that across the metered flow orifice. As a result, the metered flow is always proportional to the quantity of the main flow passed.



WHEEL BRAKE SYSTEM

FTX80157

Figure 32-56

(5) During normal flow cycle to the brakes, the piston does not travel the entire stroke, because the limiters rated capacity is larger than the portion of the brake system it protects.

(6) If a brake line should break, the piston travels the entire stroke, contacting the shoulder of the sleeve, and preventing further flow to the brake. Once closed, the brake line remains closed until the inlet pressure is reduced to approximately 5 psi. Reduction of inlet pressure permits the spring to resume its original position and return the main piston to its static position, preparing the fluid quantity limiter for another cycle.

(7) In normal operation, the check permits a small quantity of fluid passage to the brake to preclude the possibility of the limiter closing at extremely low flow rates, such as parking brake application over a period of time. Any reverse flow upsets the check to permit free flow through the limiter. A small metering orifice also acts as a check valve, since the orifice is displaced from its seat to permit free exit of the fluid which previously moved the main piston to the seated position.

(8) If a hydraulic failure occurs, the emergency airbrake system will be used and air will be ported to the shuttle valve. With no hydraulic pressure to oppose it, the air pressure overrides the poppet spring and permits air to enter the brake lines and operate the brakes. Whenever the airbrake system is used, air is introduced into the hydraulic lines downstream of the shuttle valve and fluid quantity limiters. This will necessitate bleeding the brake system and charging the airbrake air bottle.

11. Antiskid System - Description and Operation (Mark II)

A. General (See Figure 32-57)

(1) The antiskid system is a completely automatic, electrically controlled means of preventing each individual main gear wheel from skidding during brake application. The system consists of a solid state circuitry control box, eight wheel speed transducers, four dual servo valves, a fail indicating light, and a system arming control switch. The system has a locked wheel protection feature which prevents braking action before wheel rotation. The system is controlled by a 2-way position switch which will arm or deactivate the system. When the system is

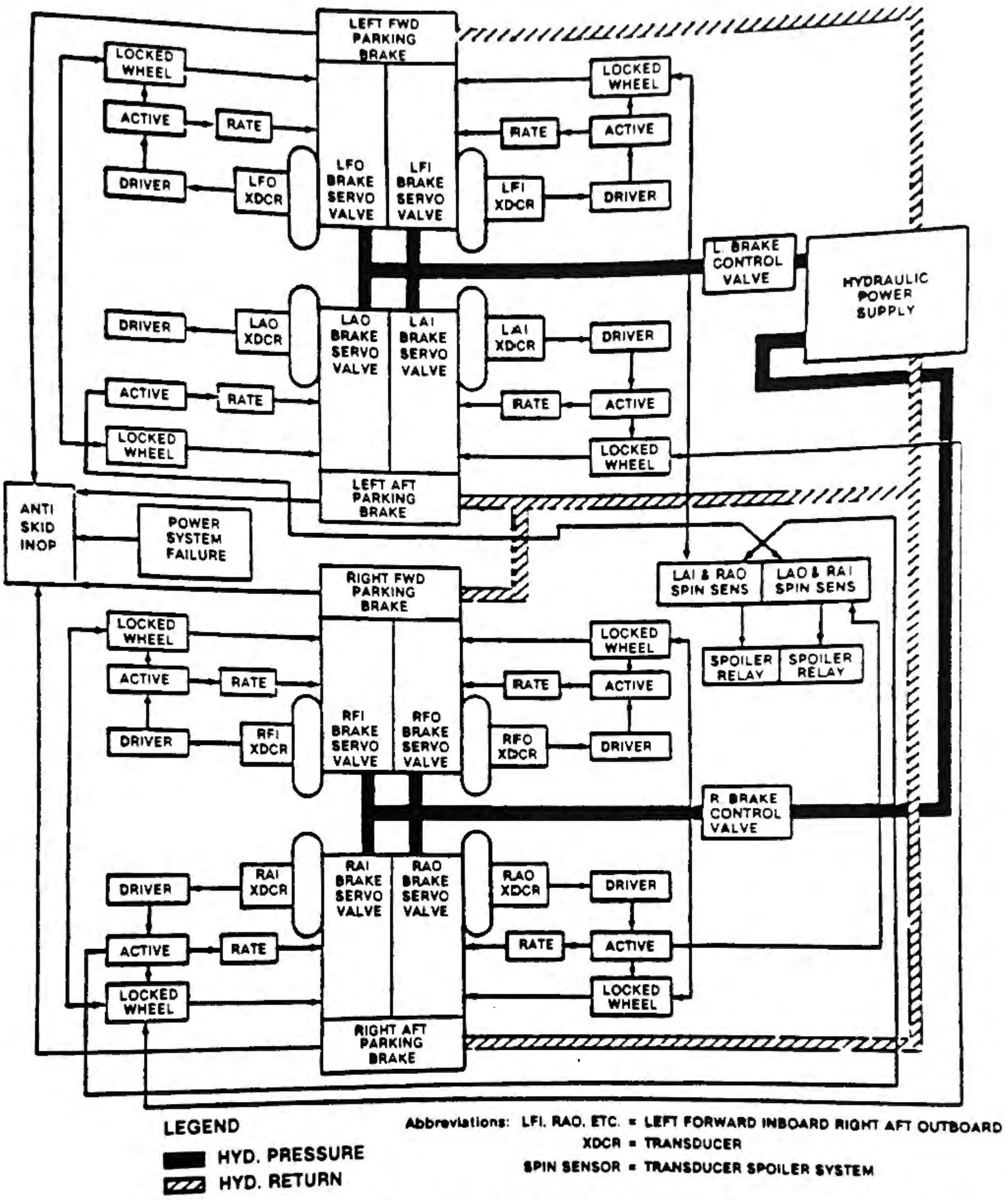
deactivated, the wheel brakes are controlled manually through the brake control valves and the brake pedals. When the antiskid system is armed, the brakes are controlled by the dual servo valves, which meter the hydraulic pressure which is supplied by the brake control valves through the captain's metered application of the brake pedals.

(2) Antiskid protection is accomplished through the control of wheel torque at the point of maximum braking efficiency, just before impending skid. This point, however, changes continuously as the airplane moves down the runway, since there is a greater weight on the landing gear and larger tire footprint area, as well as changing environmental conditions on the runway. Yet, whatever, the airplane or runway conditions, the antiskid system's self-adaptive modulation continuously determines the maximum pressure at which braking can be utilized and automatically applies that pressure.

(3) Basically there are three elements to the antiskid system: the frequency generating wheel speed transducers, which follow the speed change of the wheels; the control box circuitry, which computes appropriate valve voltage on the basis of that information received from the transducer; and the servo valve, which modulates brake pressure on the basis of that signal received from the control box for optimum brake performance.

B. Antiskid System Control Box

(1) The control box contains one solid-state, printed circuit card for each main gear wheel, a spoiler circuit card, and a light logic card. Each wheel card is divided into two basic circuits, a control circuit and a memory circuit. The control circuit senses the rate of wheel departure from free rolling wheel speed, while at the same time rejecting false skid signals generated by mechanical noise or normal wheel deceleration of the slowing airplane. The sensing of rate-of-change of wheel speed, rather than wheel speed itself, creates an anticipatory feature which provides the high response necessary for wheel torque control. The memory circuit provides the delineation, or reference curve, to which the sensor information is compared to produce this anticipation.



LEGEND

■ HYD. PRESSURE
▨ HYD. RETURN

Abbreviations: LFI, RAO, ETC. = LEFT FORWARD INBOARD RIGHT AFT OUTBOARD
XDCR = TRANSDUCER
SPIN SENSOR = TRANSDUCER SPOILER SYSTEM

ANTISKID SYSTEM -- BLOCK DIAGRAM

FTX80158

Figure 32-57

C. Antiskid System Wheel Speed Transducers (See Figure 32-58)

(1) The wheel speed transducers are variable reluctance, since wave generators driven by each main gear wheel to produce a voltage input into the control box and lend a basis for variation detection in wheel speeds. A wheel speed transducer is installed in the axle of each main gear wheel, is coupled to the wheel hub cap, and is bidirectional; its output is the same in either direction of rotation. A fixed, wound coil provides the magnetic field of the transducer; wheel rotation produces variations in the magnetic air gap at 50 cycles per revolution. This is accomplished by rotation of a toothed rotor inside a mating toothed stator segment. The flux changes thus produced induce an ac component on the dc input line. The frequency of this ac component is sensed as wheel speed by the control box circuit.

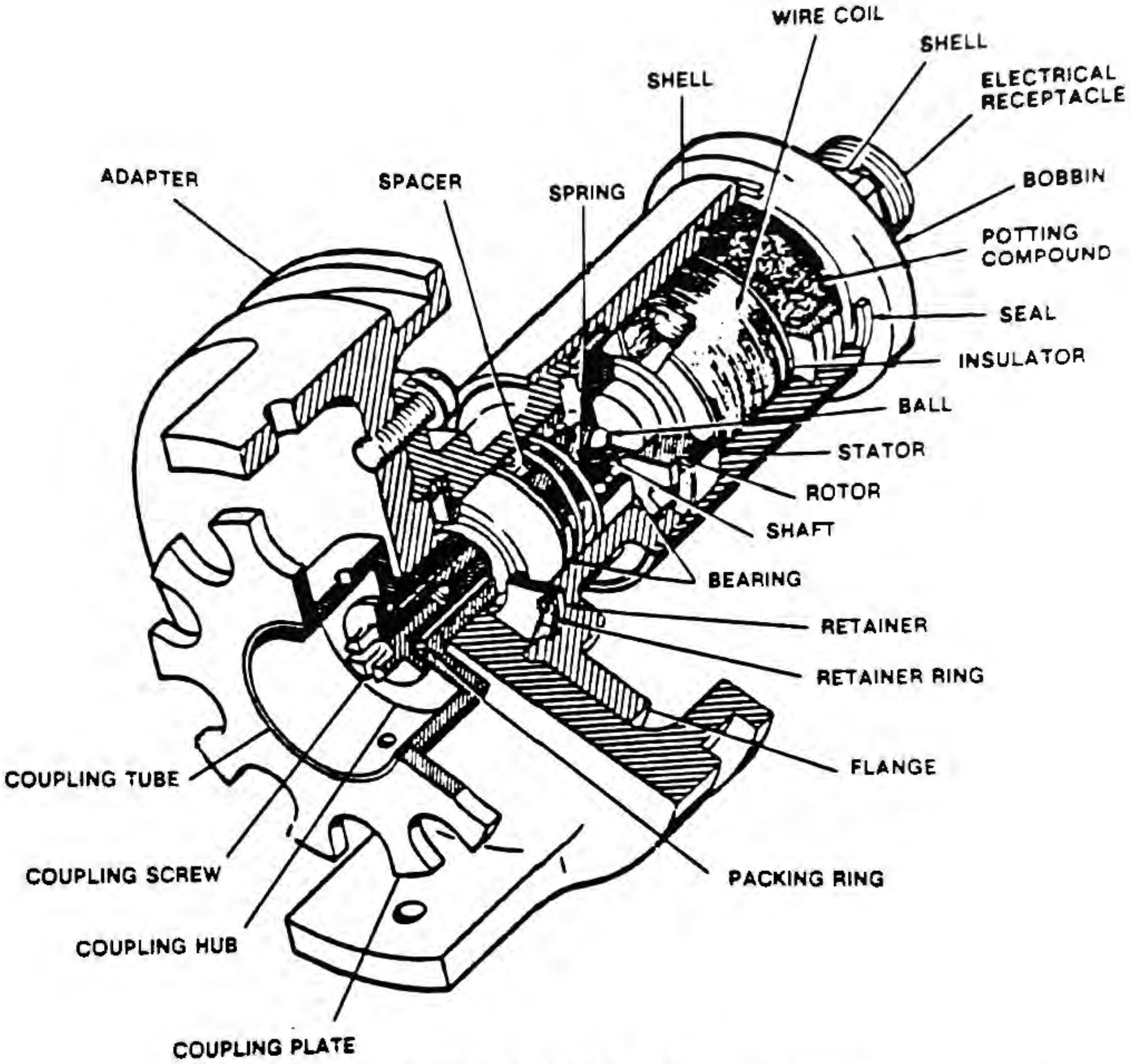
D. Antiskid System Dual Servo Valves (See Figure 32-59)

(1) The antiskid dual servo valves are electrically operated, slave motoring, hydraulic valves used in the antiskid system to prevent wheel skidding during brake application. The dual servo valve consists of an aluminum housing with a pressure inlet port, a return port, two brake pressure ports, and an electrical receptacle.

(2) Internally, the valve contains one 10 micron inlet filter, two 20 micron internal passage filters and orifice valves, two check valves, one pressure relief valve (cracking pressure 3500 psi), one solenoid operated shutoff valve (normally closed), one (dry) torque motor which operates the first stage flapper-nozzle valve, one second stage pressure feedback chamber, two feedback pistons, one return shutoff poppet valve, and several internal porting passages. Except for the sleeve and piston, which are honed and lapped stainless steel, the complete valve is made of aluminum. All filters are sintered metal filters.

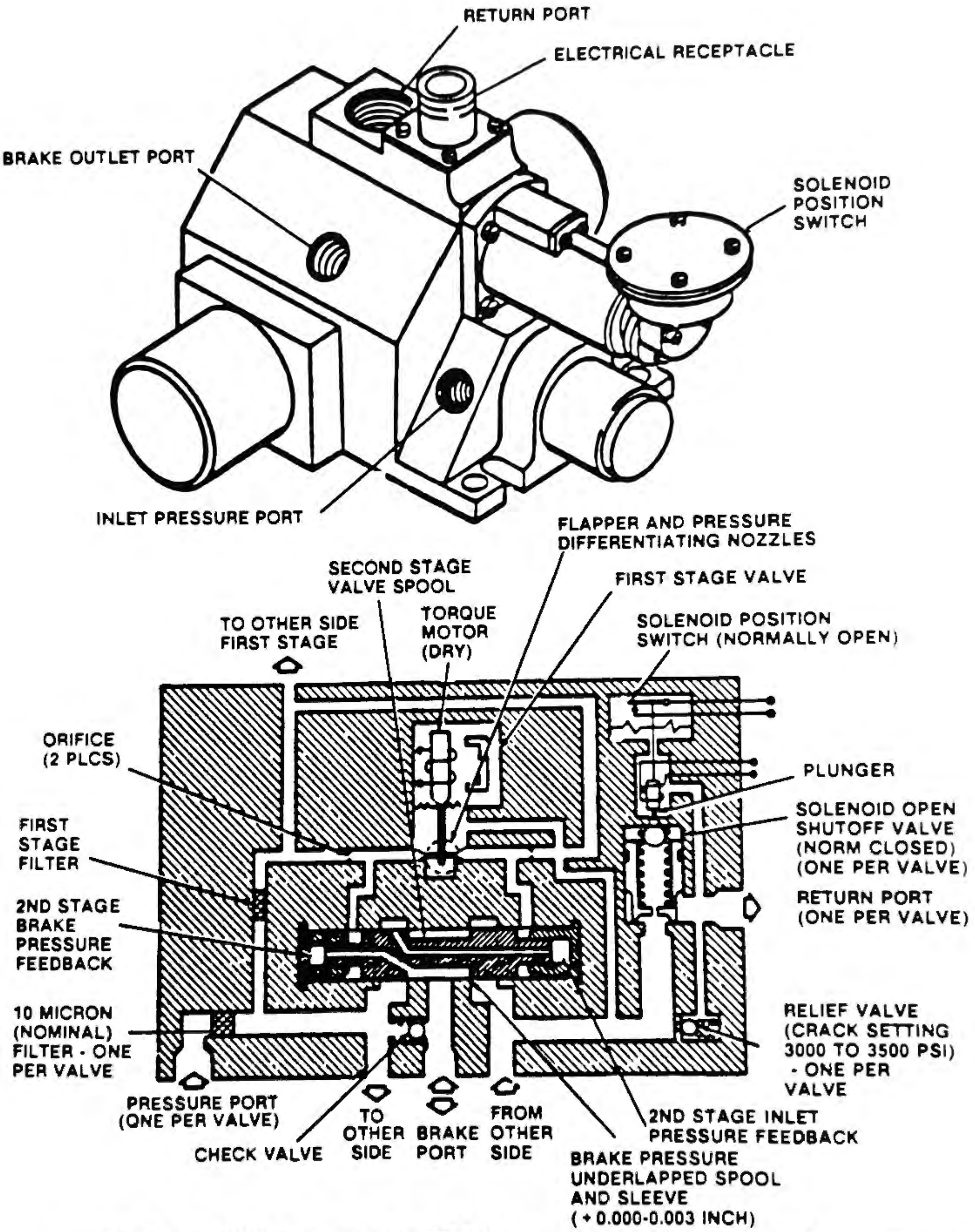
E. Operation

(1) In flight, the antiskid system is armed by placing the landing gear control lever in the down detent position. At this time an artificial wheel spinup signal is applied to the locked-wheel amplifier in each wheel card. This applies maximum pressure bias voltage to the servo valve causing it to assume a dump position. This prevents accidental application of brakes prior to touchdown and wheel spin up.



WHEEL SPEED TRANSDUCER -- CUTAWAY FTX80159

Figure 32-58


RETURN PORT
ELECTRICAL RECEPTACLE
BRAKE OUTLET PORT
SOLENOID POSITION SWITCH
INLET PRESSURE PORT
FLAPPER AND PRESSURE DIFFERENTIATING NOZZLES
SECOND STAGE VALVE SPOOL
FIRST STAGE VALVE
TO OTHER SIDE FIRST STAGE
TORQUE MOTOR (DRY)
SOLENOID POSITION SWITCH (NORMALLY OPEN)
ORIFICE (2 PLCS)
PLUNGER
FIRST STAGE FILTER
SOLENOID OPEN SHUTOFF VALVE (NORM CLOSED) (ONE PER VALVE)
RETURN PORT (ONE PER VALVE)
2ND STAGE BRAKE PRESSURE FEEDBACK
10 MICRON (NOMINAL) FILTER - ONE PER VALVE
RELIEF VALVE (CRACK SETTING 3000 TO 3500 PSI) - ONE PER VALVE
PRESSURE PORT (ONE PER VALVE)
CHECK VALVE
TO OTHER SIDE
BRAKE PORT
FROM OTHER SIDE
2ND STAGE INLET PRESSURE FEEDBACK
BRAKE PRESSURE UNDERLAPPED SPOOL AND SLEEVE (+0.000-0.003 INCH)

ANTISKID SYSTEM DUAL SERVO VALVE -- SCHEMATIC FTX80163

Figure 32-59

(2) At touchdown, as the wheels spin up, the transducers develop an ac voltage which causes the locked-wheel amplifier to cut off and the pressure bias voltage begins to decay as the locked-wheel protection memory develops. The antiskid system is now fully functional, permitting the power brake control valve hydraulic pressure to be applied to the brakes when the brake pedals are depressed.

(3) During ground roll, with the brakes fully applied, modulation of the pressure bias provides the mean pressure level usable at each wheel brake and permits wheel skid control to operate about this mean. This results in fast, efficient control of brake torque, since only small pressure changes are necessary. The pressure bias modulation circuit mean level is achieved by integrating the amplitude and duration of the control signal. Therefore, as a wheel recovers from a skid and the rate control signal ends, the bias voltage on the valve remains proportional to the time integral of the amplitude and duration of the last signal added to the bias generated by the preceding skids. The bias results in a pressure from the servo valve so that as bias voltage increases, pressure decreases. This bias will decrease in the absence of a skid signal according to the time characteristic determined for the airplane. Thus, upon recovery of a wheel to normal speed, brake pressure will come on at a slightly lower level than when the skid occurred. This sampling of skid pressure and corresponding correction of bias level occurs constantly throughout the ground roll, because skid pressure levels are constantly changing.

(4) The locked-wheel control circuit operates in the following manner. The wheel speed transducer frequency pulses are converted into a dc voltage constant over the airplane speed range from maximum to approximately 15 knots. A comparator amplifier measures a voltage for all other wheels. If the voltage drops, an overriding signal is sent to the valve driver effecting full pressure release at the locked wheel. On wet runways, with very small coefficient of friction, a skidding or stopped wheel would take longer to recover to synchronous speed. Normal reapplication of pressure would be too fast. The control box memory circuits remember what the wheel speed was before skidding and allow the wheel to recover to very near that speed before reapplication of pressure. However, as the pressure returns, it does not return to the former level, but to a lower level, and is allowed to increase slowly as the pressure bias modulation circuit discharges.

(5) The wheel speed transducers have no direct effect on the antiskid system before touchdown. Immediately upon touchdown, the wheels begin to spin and the transducers supply a voltage to the control circuit. From this point to the cutoff point (approximately 15 knots), the wheel speed transducers sense any variation in wheel rotation speed. Since each wheel transducer controls an individual wheel brake, a variation at the individual level will cause a brake release, for a brief time, at that wheel. Should any individual wheel speed transducer fail, the corresponding brake servo valve will relieve all pressure to that brake and the wheel will roll free until the speed decreases to approximately 15 knots. When wheel speed decreases to approximately 15 knots, the velocity signal produced by the other transducers will drop to a level that deactivates the antiskid system and reverts the braking system to manual operation.

(6) During normal brake operation, with the antiskid system deactivated, the dual servo valves are ported to permit the brake control valves to supply pressure for brake application. When the antiskid system is armed, brake pressure is metered to the servo valves through the control valves and the servo valves function as follows. A force balanced slave metering valve is controlled by a flapper-nozzle first stage. A force balance is set up between the inlet (pilot's metered) pressure and the brake pressure outlet by means of feedback pistons in the ends of the slide. As long as no differential pressure is applied by the flapper-nozzle valve, the slide forces are balanced (with outlet pressure equal to inlet pressure) and the slide is held open by a spring. When a skid signal is applied, the servo pilot stage applies a differential pressure to the slide ends and unbalances it toward the return port. Brake pressure is then metered down until the differential force between the feedback pistons equals the differential force created across the spool. At this point the spool is again balanced and centered with both inlet and return closed to the brake. When the skid signal is reduced or removed, the reverse action occurs. The spool spring force adds about 50 psi bias in the open direction. The pilot's metered pressure is fed directly to the brakes as long as no electrical (skid) signal is applied. When a skid control signal is applied, the ratio of brake pressure to pilot's metered pressure is reduced in proportion to the signal strength.

(7) A small, normally closed, solenoid-operated shutoff valve is used on the dual servo valves to shut off fluid flow through the servo pilot section whenever parking brakes are required. The only leakage in this condition is from the slave section which amounts to 1 cc/min maximum per valve.

(8) An electrical switch is coupled to the normal bleed port solenoid operated shutoff valve plunger. The solenoid is actuated when the antiskid system is armed and opens the return port. During power off, or in the parking mode, this return port is closed by the deactuated solenoid. The switch completes a ground circuit for the antiskid indicating light to notify the captain that one, or more, of the brake servo valves may be inoperative and the corresponding brakes have reverted to manual operation.

(9) The antiskid inoperative light (fail) is provided with a ground circuit by the light logic card in the antiskid control box.

(10) This ground path is withheld during normal operation of the antiskid system. A light on condition can indicate a power failure to the antiskid control box, that the arming switch is in the off position, that the parking brakes are set or that the solenoid actuated switch in the brake servo valve, or valves, has failed to open. Failure of the light logic card in the antiskid control box will have no effect on the control of the antiskid braking system, but effects the fail indicating light by producing either a continuous light or no light.

12. Antiskid System - Description and Operation (Mark III)

A. General (See Figure 32-60)

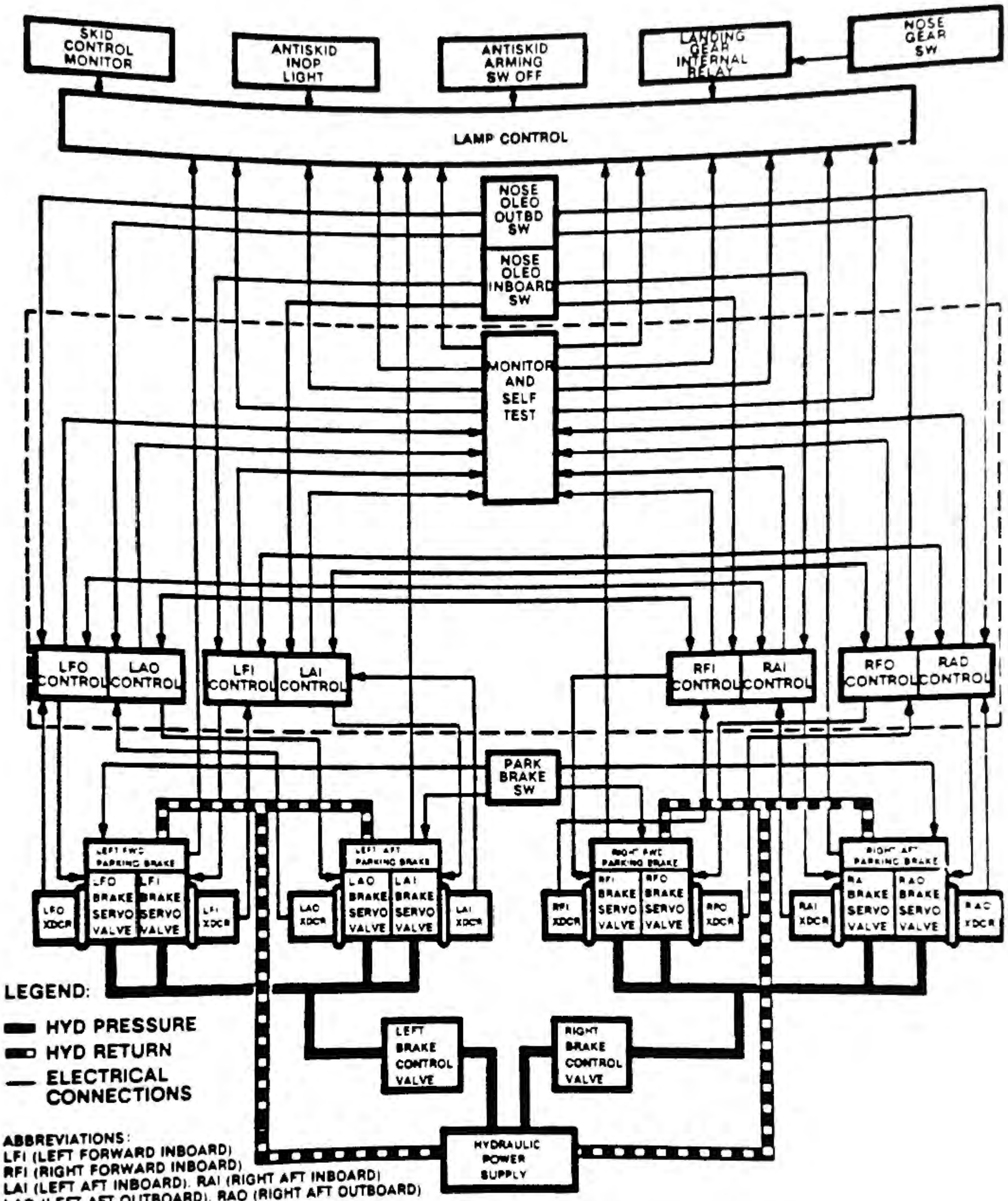
(1) The antiskid system is an electro/mechanical means of obtaining maximum allowable torque from each main gear wheel brake while protecting each tire from uncontrolled skidding. The basic system consists of a control box (containing four solid state wheel control cards), eight wheel speed transducers, four dual servo valves, an ANTI SKID INOP light and an arming control switch. The system is primarily armed by a two-position switch (antiskid off-armed) and the system is disarmed when the landing gear lever is selected to the up position and rearmed when the landing gear selector lever is placed to down. Inadvertent application of pressure to the brakes, prior to touchdown and spinup of the wheels, is prevented by the nose oleo

operation of two switches. These two ground-seeking circuits (open in flight) force the individual wheel cards valve drivers to maximum bias voltage and place the servo valves in the full dump position. Wheels spinup velocity signals to the wheel cards that overrides the inflight touchdown locked wheel protection and with the pilot's brake valve pressure applied braking may now begin.

(2) The wheel speed transducers and servo valves are constantly monitored by two solid state auxiliary cards contained in the control box. Monitored faults are used to switch a separate lamp control unit which then provides a ground signal to the appropriate wheel lamp(s) in the cockpit skid control monitor unit and to the pilot's ANTI SKID INOP lamp. A solid state test card, a rotary wheel selector switch, three push button switches and a meter mounted on the control box front panel provides self test capability.

(3) The Mark III skid control functions by comparing the velocity of the tire of a braked wheel to a reference (simulated aircraft) velocity that is initially established in each control circuit at spinup. This provides a dynamic reference velocity about which to establish the tire slip velocity error signal required for system control. The wheel velocity signal passes through a lag circuit whose time constant reflects the relative masses of the aircraft and the individual wheel and provides the reference deceleration. The reference deceleration then operates provide the dynamic reference velocity. The difference between the reference velocity and the measured wheel velocity is the error signal that is acted upon by the pressure bias modulation (PBM) and transient control circuits. The PBM is the primary control and establishes the required brake pressure needed to maintain the brake at the torque level needed to maintain maximum deceleration of the aircraft. The transient control is a parallel and a rapid means of lowering brake pressure when a tire comes into contact with a low friction surface (tar strip, paint strip, puddle, ice patch, etc.). As wheel speed is recovered the brake pressure is reapplied quickly under PBM control.

(4) Another function of skid control is roll-out locked wheel protection which is provided by coupling the wheels in four groups of two each.



LEGEND:
- ▬ HYD PRESSURE
- ▭ HYD RETURN
- — ELECTRICAL CONNECTIONS

ABBREVIATIONS:
LFI (LEFT FORWARD INBOARD)
RFI (RIGHT FORWARD INBOARD)
LAI (LEFT AFT INBOARD), RAI (RIGHT AFT INBOARD)
LAO (LEFT AFT OUTBOARD), RAO (RIGHT AFT OUTBOARD)
LFO (LEFT FORWARD OUTBOARD)
RFO (RIGHT FORWARD OUTBOARD)
XDCR - TRANSDUCERS

ANTISKID SYSTEM -- BLOCK DIAGRAM

FTX80161

Figure 32-60

(5) This cross coupling enables generation of a differential voltage, should the wheel speed signals sufficiently differ. This voltage is then used to override control (or loss of control) of the slow wheel and to release brake pressure. The differential voltage level developed is a function of velocity and is ineffective at taxi speeds.

(6) Basically there are three elements to the antiskid system: the wheel speed transducers which follow the speed of the wheel; the antiskid control box which monitors the transducer output and computes appropriate valve control voltage; the dual servo valves which modulate braked pressure in response to the control voltage received from the antiskid control box.

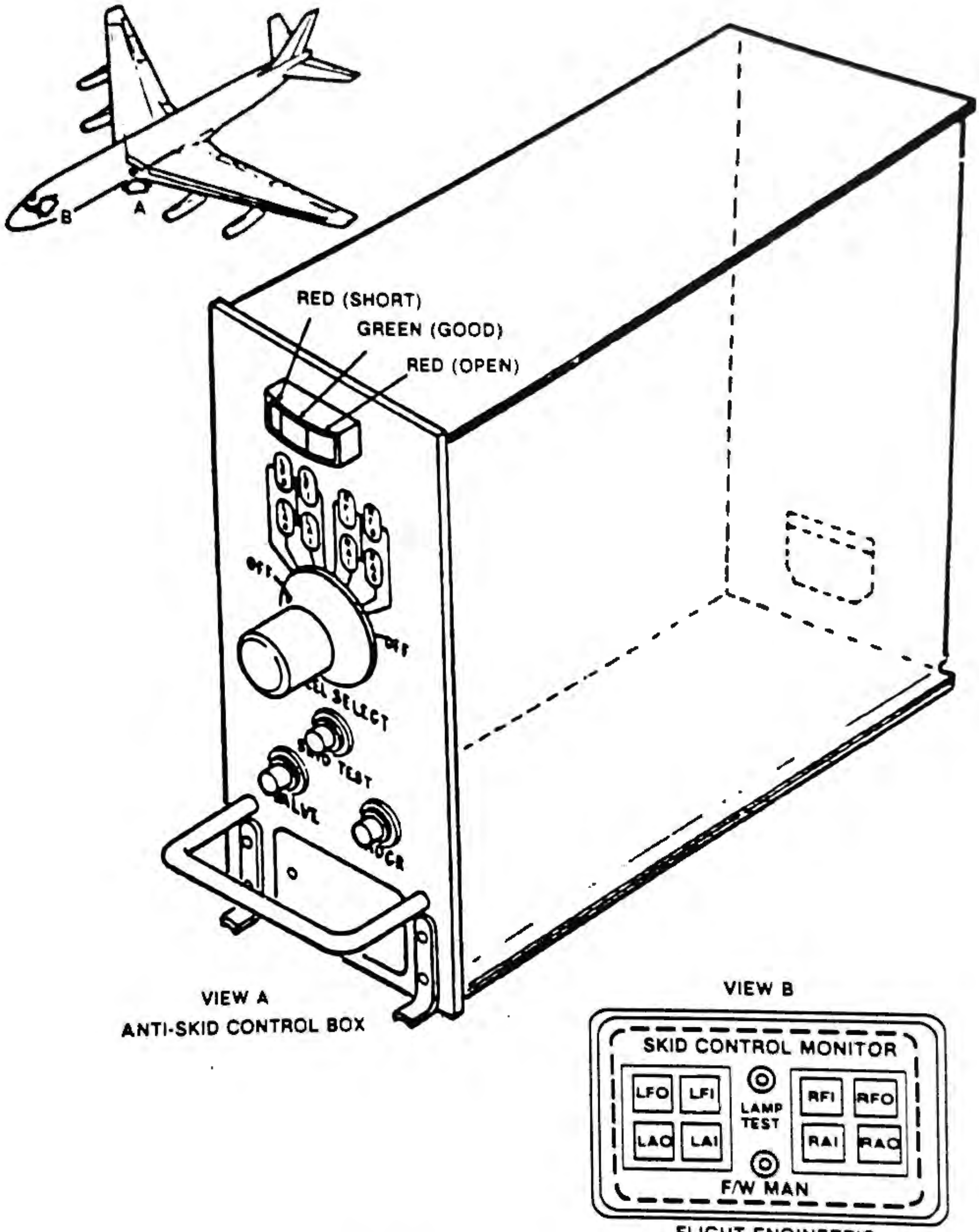
B. Antiskid System Control Box (See Figure 32-61)

(1) The antiskid control box contains four dual solid state printed circuit cards that provide all the main gear wheel antiskid control functions. In addition, there are three solid state printed circuit cards that provide the continuous fault monitoring and self test capability. The circuitry for each wheel monitors the aircraft mode of operation and wheel speed and computes the valve control voltages necessary to provide touchdown locked wheel protection, roll-out locked wheel protection, and pressure metering control signals.

C. Antiskid System Wheel Speed Transducers (See Figure 32-62)

(1) The wheel speed transducers are electromagnets used as variable reluctance, sine wave generators. This is accomplished by using a fifty toothed splined housing and a fifty toothed gear to provide a radial flux path for the electromagnet. As the gear rotates within the splined housing the flux path is interrupted fifty times per revolution.

(2) The transducer gear is coupled to the wheel hub cap to follow wheel rotation. The flux changes thus induce an ac component on the dc electrical bias voltage. This ac component is sensed as wheel speed by the control box circuit.



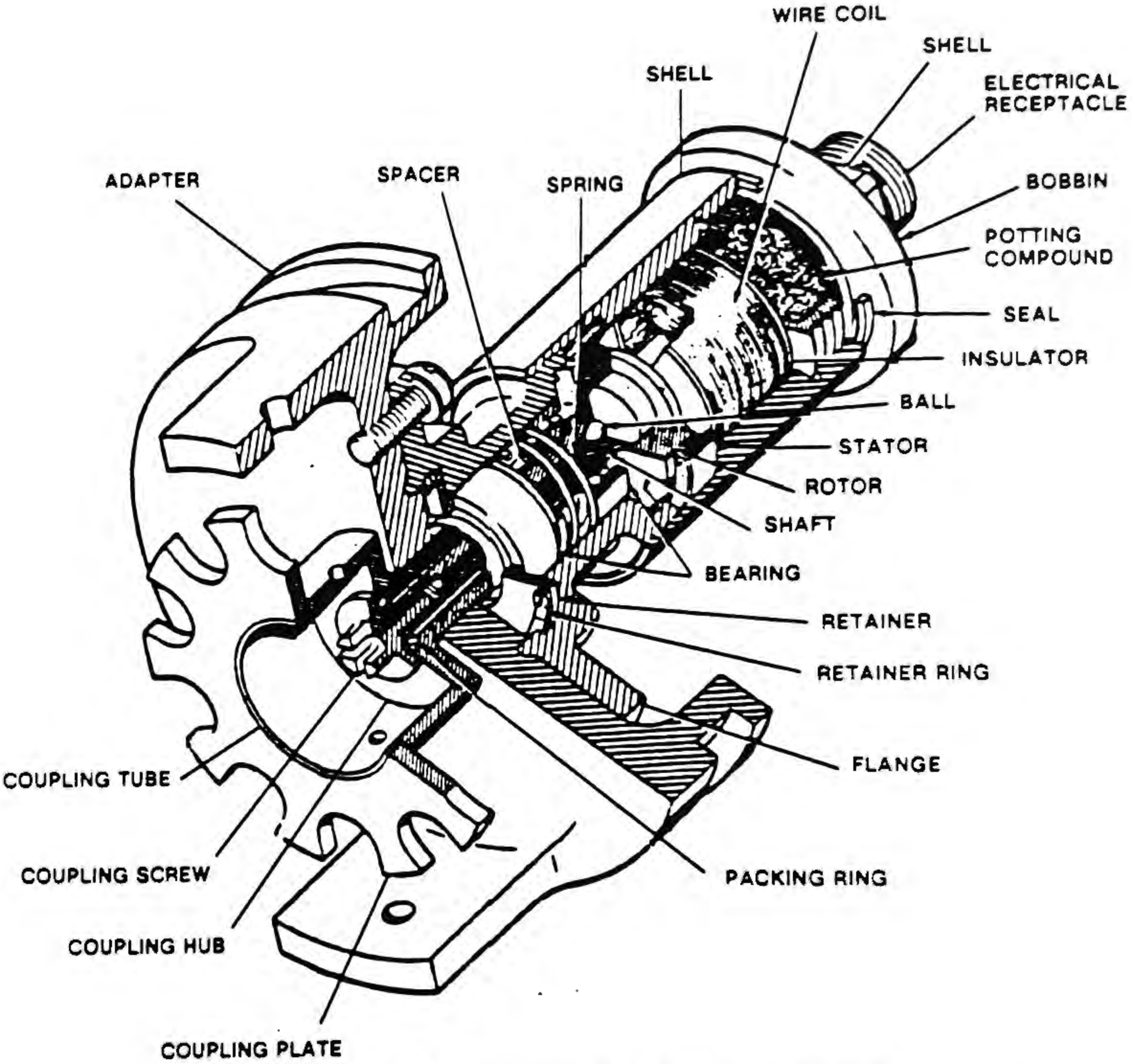
VIEW A
ANTI-SKID CONTROL BOX

VIEW B

FLIGHT ENGINEER'S
INSTRUMENT PANEL

ANTISKID SYSTEM -- INDICATORS
Figure 32-61

FTX80164



WHEEL SPEED TRANSDUCER -- CUTAWAY FTX80159

Figure 32-62

D. Antiskid System Dual Servo Valves (See Figure 32-63)

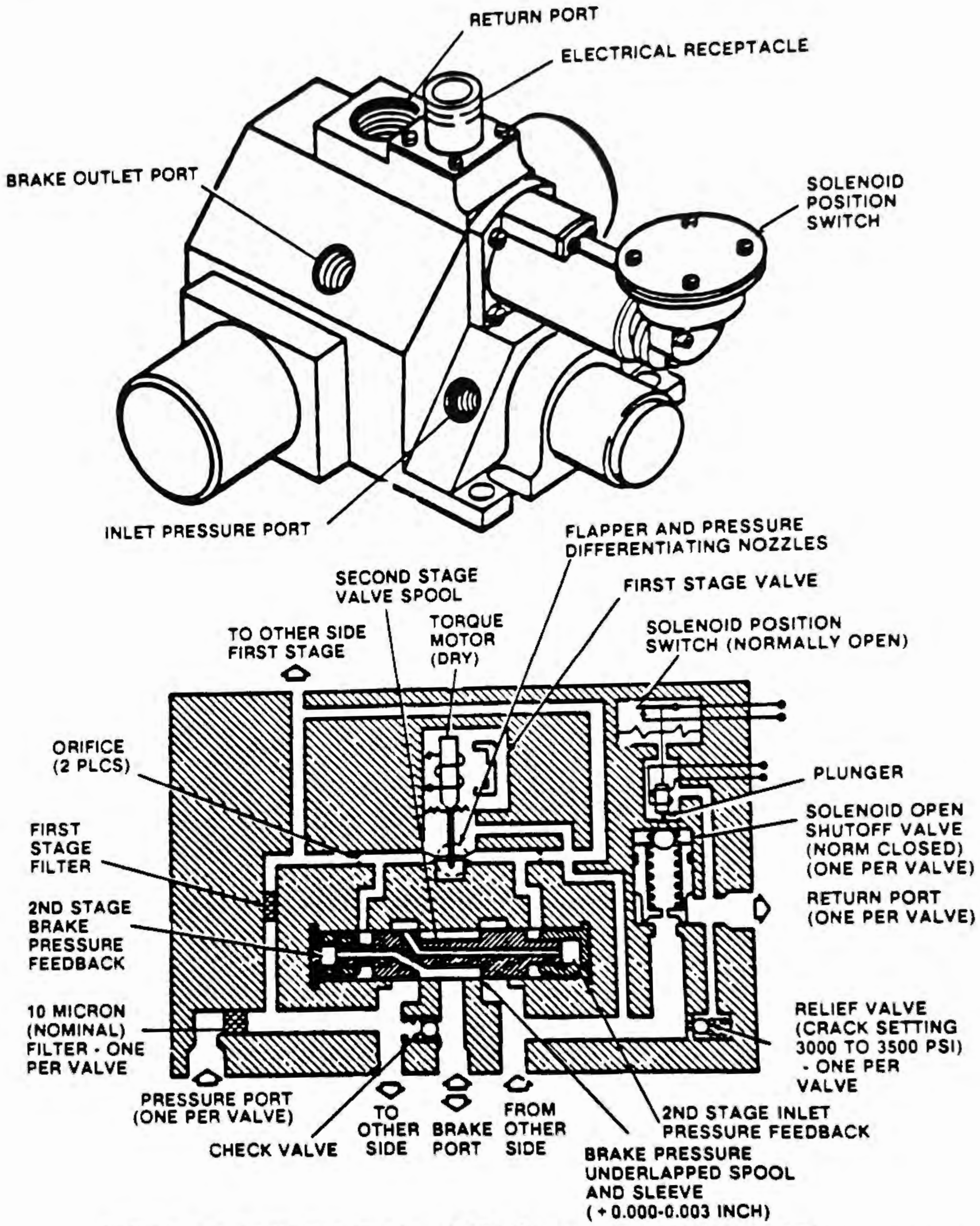
(1) The skid control dual servo valves are electrically operated, dual, two stage hydraulic metering valves with metering shutoff capability. Electrical control is exercised in the servo first stage to port control pressure to position the second stage slide and sleeve to port main hydraulic braking pressure to and from the brake. Electrical control is also provided to shut off pressure relief capability and maintain brake port pressure independent of servo function or position for parking brake capability. In addition, the shut off is monitored electrically to detect the position of the shut off, open or closed.

(2) Internally, the valve contains one 10 micron inlet filter, two 20 micron internal passage filters and four orifice valves, two check valves, one pressure relief valve (cracking pressure 3500 psi), one solenoid operated shutoff valve (normally closed), one (dry) torque motor which operates the first stage flapper-nozzle valve, one second stage pressure feedback chamber, two feedback pistons, one return shutoff poppet valve, and several internal porting passages. Except for the sleeve and piston, which are honed and lapped stainless steel, the complete valve is made of aluminum. All filters are sintered metal filters.

E. Antiskid Control Monitor (See Figure 32-61 View B)

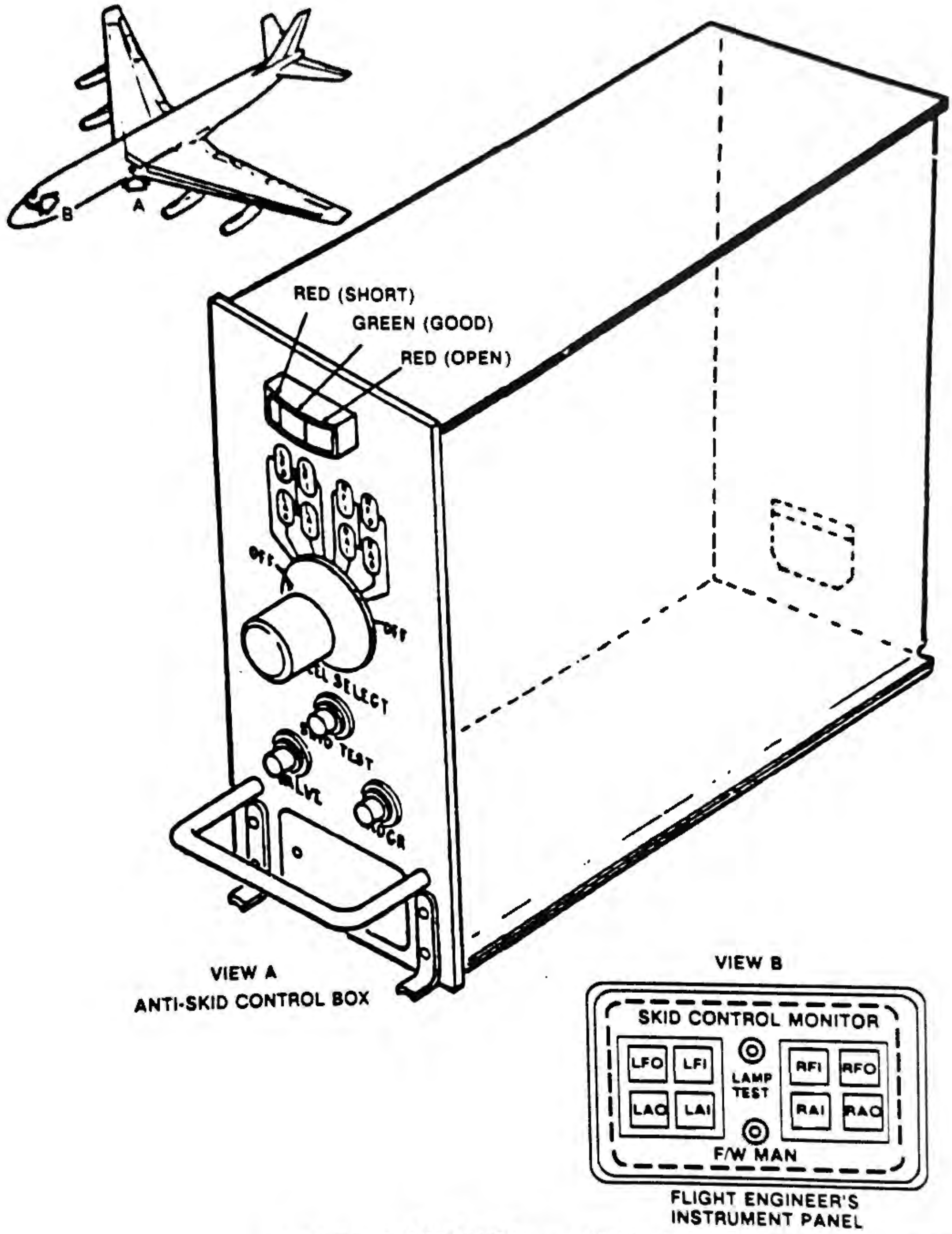
(1) The antiskid control monitor is an indicating device which has eight amber lights (one for each wheel), a press to test button, and a fault discrimination switch placarded F/W and MAN. Any faults with transducer circuits only, will be indicated normally and with the fault discrimination switch held in the F/W position. Power failure, parking brake failure, landing gear interlock failure and installation faults are also monitored when the fault discrimination switch is in the normal position.

(2) The lamp control monitors the skid control logic, the control valve logic and arming control position indications to interpret this logic for the skid control monitor and Antiskid inoperative indication. Any faults occurring in a transducer circuit valve servo or solenoid circuit or the power circuit to the control box is interpreted in the lamp control to illuminate the corresponding indicating lights on the antiskid control monitor and the ANTI SKID INOP light.


RETURN PORT
ELECTRICAL RECEPTACLE
BRAKE OUTLET PORT
SOLENOID POSITION SWITCH
INLET PRESSURE PORT
FLAPPER AND PRESSURE DIFFERENTIATING NOZZLES
SECOND STAGE VALVE SPOOL
FIRST STAGE VALVE
TO OTHER SIDE FIRST STAGE
TORQUE MOTOR (DRY)
SOLENOID POSITION SWITCH (NORMALLY OPEN)
ORIFICE (2 PLCS)
PLUNGER
FIRST STAGE FILTER
SOLENOID OPEN SHUTOFF VALVE (NORM CLOSED) (ONE PER VALVE)
RETURN PORT (ONE PER VALVE)
2ND STAGE BRAKE PRESSURE FEEDBACK
10 MICRON (NOMINAL) FILTER - ONE PER VALVE
RELIEF VALVE (CRACK SETTING 3000 TO 3500 PSI) - ONE PER VALVE
PRESSURE PORT (ONE PER VALVE)
TO OTHER SIDE
BRAKE PORT
FROM OTHER SIDE
2ND STAGE INLET PRESSURE FEEDBACK
CHECK VALVE
BRAKE PRESSURE UNDERLAPPED SPOOL AND SLEEVE (+0.000-0.003 INCH)

ANTISKID SYSTEM DUAL SERVO VALVE -- SCHEMATIC FTX80163

Figure 32-63



ANTISKID SYSTEM -- INDICATORS
Figure 32-64

FTX80164

F. Operation

(1) In flight, the antiskid system is armed by placing switch in armed position and placing landing gear control lever in down detent position. At this time, inflight signals (right and left nose oleo switches) are applied to each wheel control circuit. Maximum bias voltage is applied to the dual servo valve as a result of these signals causing them to assume full pressure release position. This prevents pressure application to the brakes prior to touchdown and wheel spinup.

(2) At touchdown, as the wheels spin up, the transducers generate a wheel speed signal. The controller responds by producing a signal to override the bias voltage and allow brake application.

(3) When the nose gear is compressed, the signal that created the bias voltage is removed as the right and left oleo switches detect the transition from nose gear extended to nose gear compressed.

(4) The purpose of removing the overridden bias voltage at ground speed is to prevent loss of brakes at low speed. The signal generated by the transducer at low speed is ineffective in overriding the flight associated bias voltage.

(5) Where the brake effort desired by the pilot is something less than optimum braking and no skid conditions are exhibited, no preventive or control action is created.

(6) The control valve acts as a "go-between", accepting electrical signals from the antiskid control box and generating the condition where a change in brake pressure results in the proper change in brake torque acting on the wheel. The control valve has two parts; a first stage flapper nozzle valve that generates a control pressure that is an input to the second stage spool. The second stage spool balances the brake pressure and the first stage pressure input against the system pressure supplied by the pilot's brake pressure metering valve. Thus, if the first stage commands a pressure input, the result will be the reduction of brake pressure.

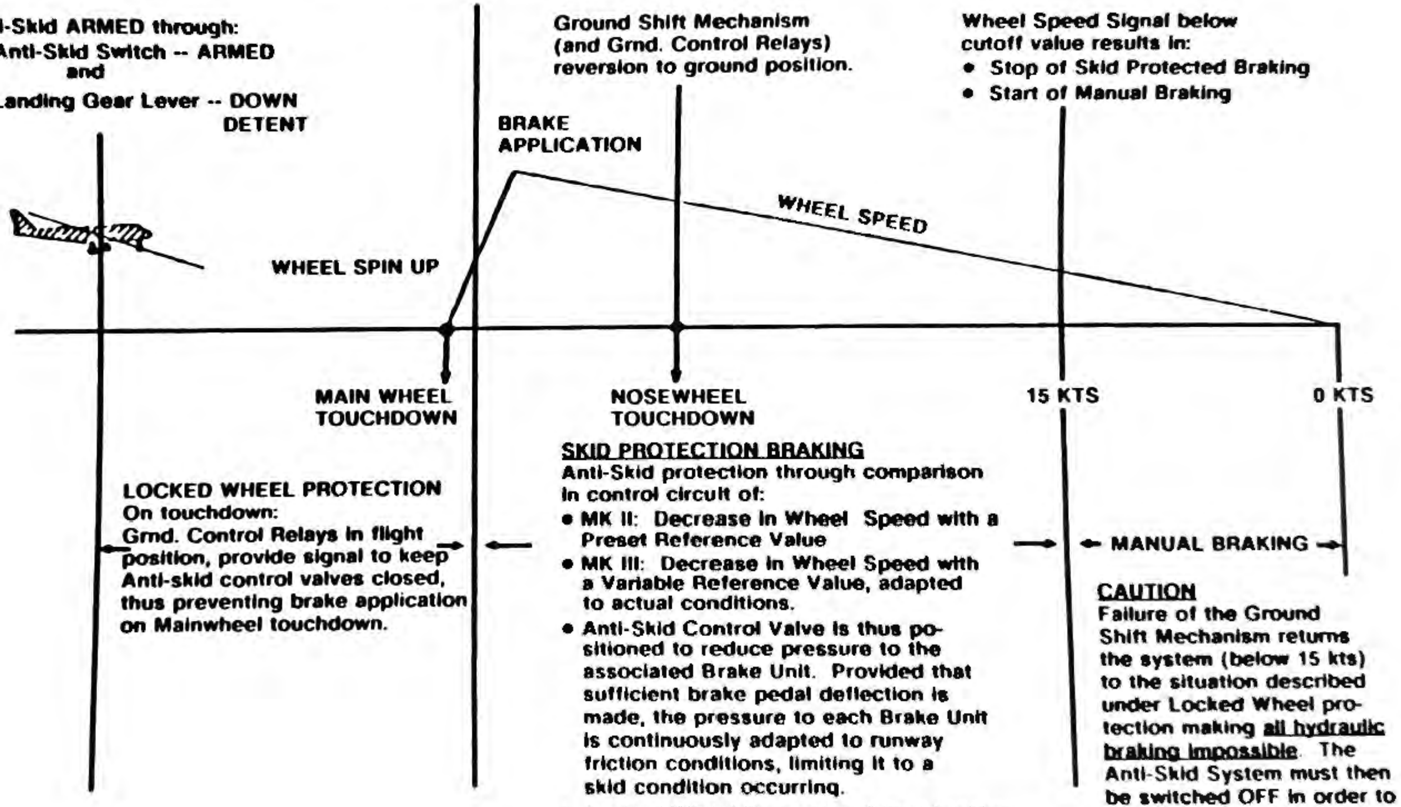
WHEEL SPIN UP

- At 15 kts: Spin up signal suppresses signal from Grnd. Control Relays for:
  - Stop of Locked Wheel Protection (landing).
  - Start of Skid Protected Braking.
- At 80 kts: Spin up signal from aft wheels provides:
  - Automatic Ground Spoiler extension.

Anti-Skid ARMED through:
- Anti-Skid Switch -- ARMED
and
- Landing Gear Lever -- DOWN DETENT

Ground Shift Mechanism (and Grnd. Control Relays) reversion to ground position.

Wheel Speed Signal below cutoff value results in:
- Stop of Skid Protected Braking
- Start of Manual Braking



LOCKED WHEEL PROTECTION
On touchdown:
Grnd. Control Relays in flight position, provide signal to keep Anti-skid control valves closed, thus preventing brake application on Mainwheel touchdown.

SKID PROTECTION BRAKING
Anti-Skid protection through comparison in control circuit of:
- MK II: Decrease in Wheel Speed with a Preset Reference Value
- MK III: Decrease in Wheel Speed with a Variable Reference Value, adapted to actual conditions.
- Anti-Skid Control Valve is thus positioned to reduce pressure to the associated Brake Unit. Provided that sufficient brake pedal deflection is made, the pressure to each Brake Unit is continuously adapted to runway friction conditions, limiting it to a skid condition occurring.
- Locked Wheel Protection during braking through comparison of Wheel Speed signals.

CAUTION
Failure of the Ground Shift Mechanism returns the system (below 15 kts) to the situation described under Locked Wheel protection making **all hydraulic braking impossible**. The Anti-Skid System must then be switched OFF in order to restore conventional hydraulic braking.

ANTISKID EVENT CHART
Figure 32-65

FTX80165

(7) The second stage port flow characteristics, the down stream line characteristics and the brake pressure-volume curve determines how fast the brake pressure can be commanded to change as a result of a command signal from the antiskid control circuit. The brake pressure, brake qualities (Geometry, Mass, Materials, etc.), and the wheel speed determine the brake torque acting to reduce the wheel speed. However, the tire runway drag force acts to increase wheel speed. Therefore, the essence of the brake control problem is to properly adjust the brake pressure so as to maintain the brake torque at the proper level (balance out tire drag force at its peak value) and give the aircraft maximum available deceleration.

(8) The return line shutoff valve is hydraulically operated and electrically controlled. The normal position of the shutoff is closed. Exhaust fluid from the servo must pass through this valve into the return line. The valve piston is spring loaded in the off position with hydraulic pressure equalized on both sides of the piston. Equalization of pressure is attained by a flow rated orifice that extends through the piston from the fluid side to the spring side of the piston. Static pressure in the chamber on the spring side of the piston limits the movement of the piston holding the exhaust fluid from entering the return line. A ball check valve provides the seal that maintains the static pressure in the chamber on the spring side of the piston. Actuation of the electrical solenoid displaces the ball in the check valve, removing the seal and releasing the pressure. The flow rated orifice in the piston limits the refill rate creating a pressure differential between the chambers on the fluid and spring sides of the pistons. This moves the piston, opens the valve and allows the exhaust fluid to pass into the return line. When the solenoid is deenergized the ball is allowed to reseal, resealing the chamber on the spring side of the piston. As the pressure equalizes the spring returns the valve to the normally closed position.

(9) An electrical switch is installed in the servo valve to monitor the position of the solenoid and provide a means of detecting the condition of the return line shut off. A pivot arm is coupled to the solenoid plunger to follow the solenoid mechanical movement. The other end of the pivot arm is used as a strike to actuate the switch when the solenoid is in the position to cause the return line to close.

(10) The switch contacts are normally open when the return line is closed. One contact on the switch is grounded to the aircraft structure and the other contact is connected to the lamp control that provides the necessary circuitry to give a warning that the skid control function, associated with that valve, is inoperative. For the condition described above the Antiskid Inop light and the two monitor lights associated with the valve are on. The switch contacts close when the solenoid is actuated indicating the return line is open. The use of normally open contacts to detect when the return line is closed also provides a warning when a valve is disconnected.

13. Emergency Airbrake System - Description and Operation

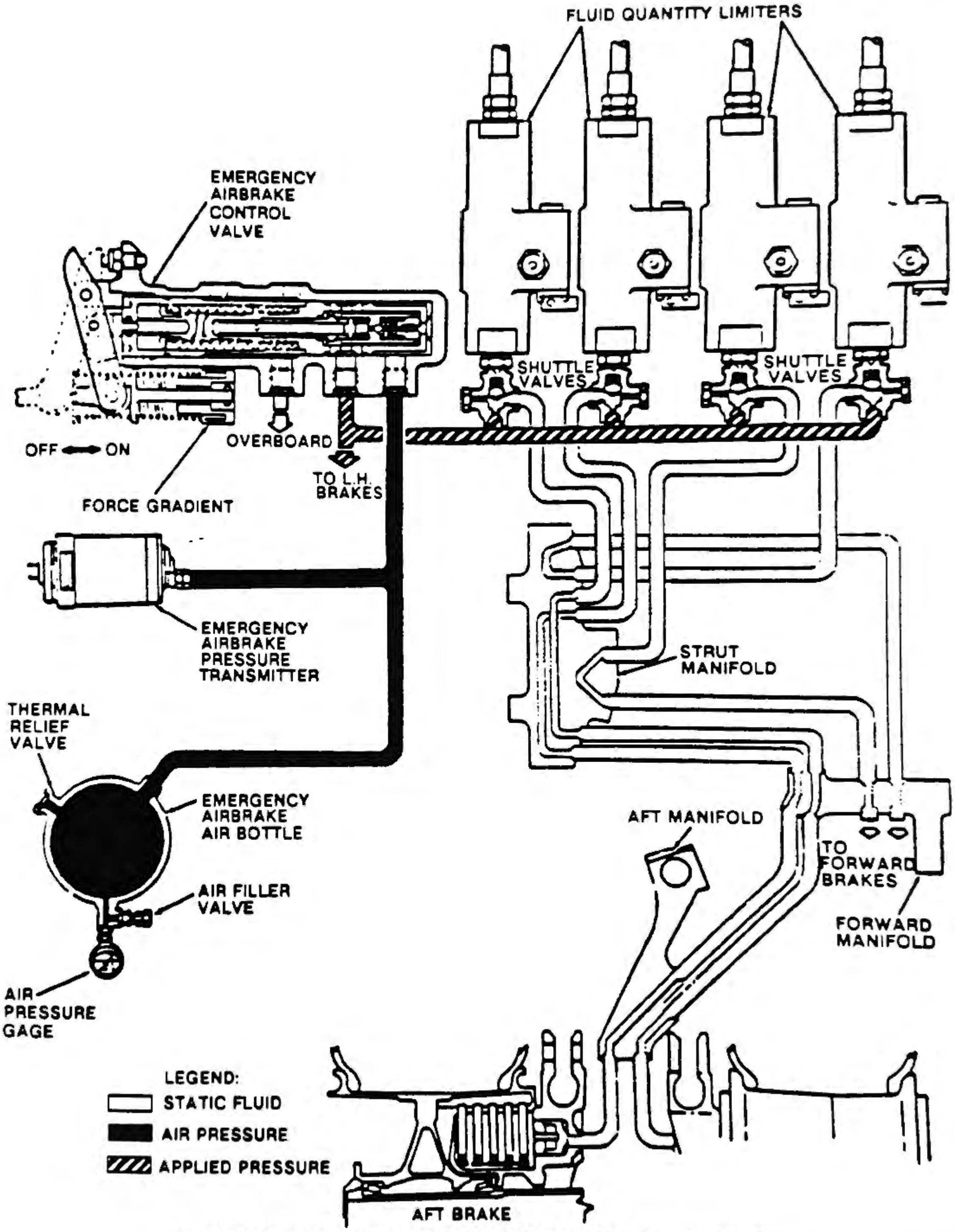
A. General (See Figures 32-66 & 32-67)

(1) The emergency airbrake system is a pneumatic backup system used to operate the main gear wheel brakes if hydraulic power is lost. The airbrake system consists of a mechanical control system to actuate the control valve, a pressure bottle to supply air pressure, a control valve to meter pressure to the brakes, a pressure transmitter and indicator to provide the flight crew with an indication of the amount of pressure available, and a shuttle valve on the downstream side of each fluid quantity limiter to port the air pressure to the brake cylinders.

B. Emergency Airbrake Control Valve (See Figure 32-68)

(1) The emergency airbrake control valve is a manually operated, balanced, variable pressure valve used to meter air pressure from the air bottle to the wheel brakes. The valve meters pressure in proportion to the lever pressure exerted by the captain through use of the control lever and mechanical control system. The airbrake control valve is located above the main hydraulic system pressure accumulator on the compression web in the left main gear wheel well.

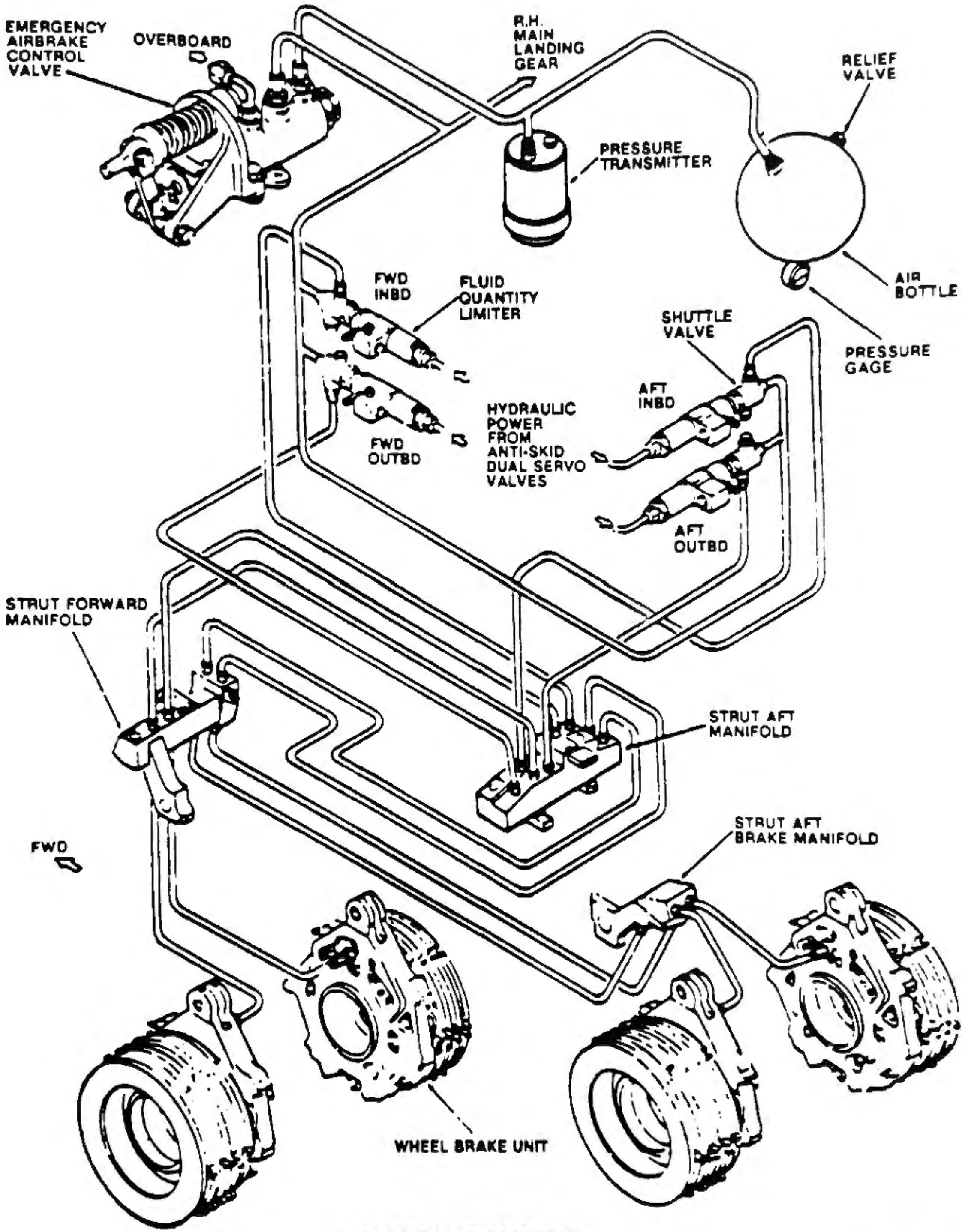
(2) Externally, the airbrake control valve consists of a body, an actuating lever, a set screw, and a yoke. The body has three ports: inlet, outlet, and exhaust port. The inlet port is piped to the air bottle, the outlet port is piped to the brake shuttle valves, and the exhaust port is piped overboard. A clevis provides the pivot axis for the valve actuating lever. Below the clevis is an adjusting screw used to limit the overtravel of the lever in the off direction.



EMERGENCY AIRBRAKE SYSTEM SCHEMATIC

FTX80166

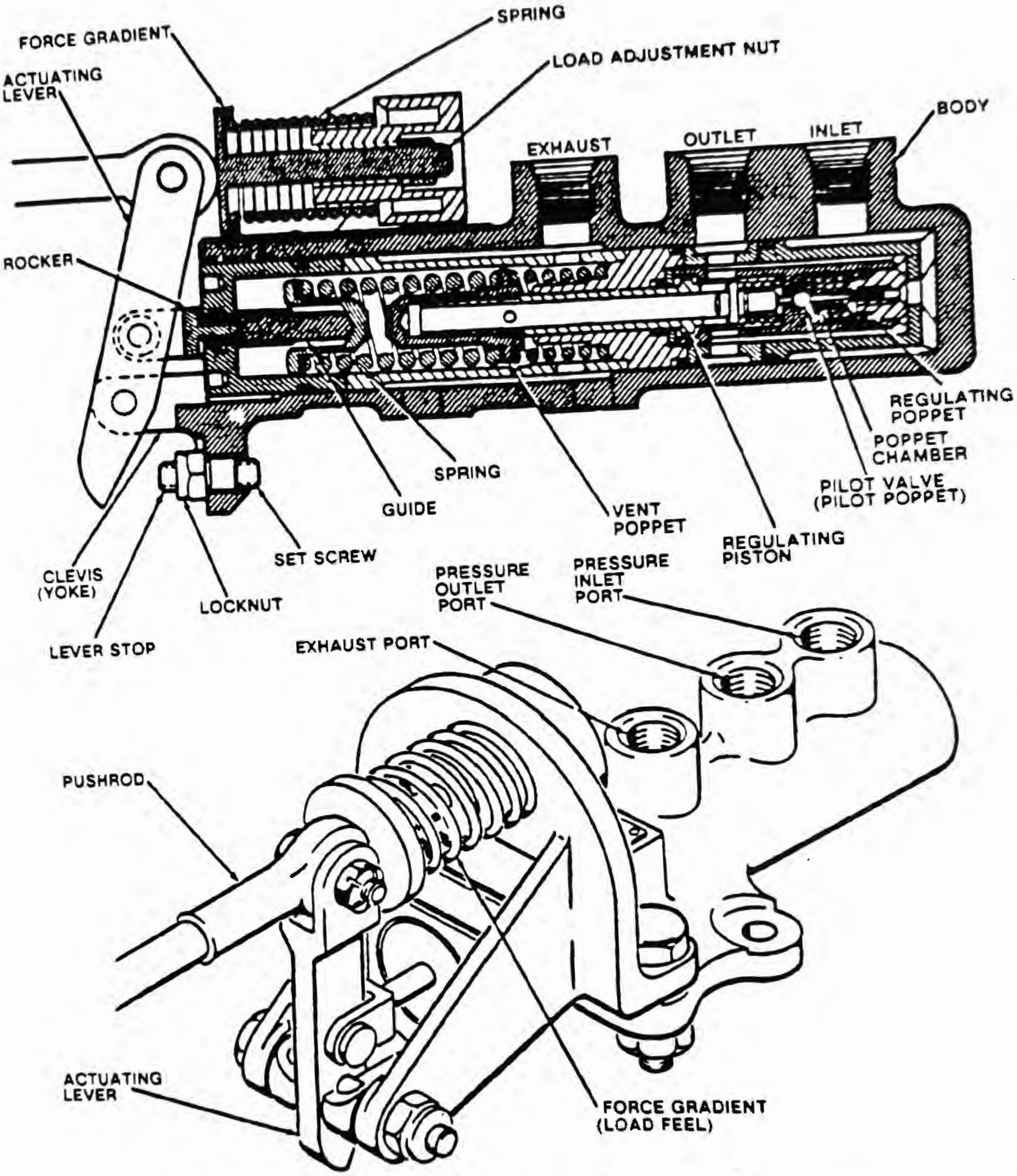
Figure 32-66



AIRBRAKE SYSTEM

FTX80169

Figure 32-67



EMERGENCY AIRBRAKE CONTROL VALVE CUTAWAY FTX80167

Figure 32-68

(3) An external load-feel spring assembly is attached to the upper side of the valve body and works against the valve lever. The external spring is adjusted to provide an abrupt load-feel increase at the point the valve allows initial air pressure (5 to 50 psi) application to the brakes. This point is identified on the control lever placard, located in the flight compartment, as brake starts. The other two placarded positions are off, and maximum pressure.

C. Emergency Airbrake Pressure Bottle

(1) The emergency airbrake pressure bottle is a spherical, steel container used for storing dry nitrogen under pressure at 3000 psi for use in the emergency airbrake system. The pressure bottle is located in the forward portion of the right wing root area, and is bolted to a bracket attached to the auxiliary spar web. The bottle is constructed of two halves welded together to form a sphere 8 3/4 inches in diameter. Three threaded ports in the bottle are used for the supply line, pressure gauge, and relief valve. The bottle pressure relief valve, used to relieve excessive pressure build-up due to thermal expansion, relieves at 4500 (+250) psi.

D. Emergency Airbrake Pressure Transmitter and Indicator

(1) The emergency airbrake pressure transmitter and indicator provide the flight crew with indication of pressure in the airbrake system bottle available for use in the system. The indicator is a synchro-type instrument, clamp mounted in the flight compartment and placarded airbrake pressure. The transmitter is mounted on the compression web 20 inches aft of the rear spar by cushion clamps. The transmitter pressure line is connected, through a snubber, to the airbrake pressure line between the air bottle and the airbrake control valve. The transmitter is used to transmit emergency airbrake bottle pressure indication to the synchro-type indicator in the flight compartment.

E. Operation

(1) With the airbrake control valve in the full off position, inlet pressure is sealed by the poppet, aided by a spring and the differential in area exposed to the outlet chamber. With increasing inlet pressure, the poppet seat loading will increase producing the required seating force to seal pressure. This variable seat loading improves the sensitivity for regulation.

(2) The outlet port is chambered to the vent port through the regulating piston. Depressing the lever will close the vent port. With further actuation of the lever, the abutment will open the pilot valve, which decreases the pressure in the poppet chamber, creating a pressure differential across the poppet allowing it to lift under controlled flow.

(3) When regulated pressure is reached at the outlet, the piston moves back, closing the pilot valve and increasing the poppet chamber pressure, producing the sealing load on the poppet to close the inlet. If the outlet pressure exceeds the set pressure, the vent poppet will momentarily open to adjust to its setting. This mode of operation is continually adjustable to the full on position.

(4) Regulation is maintained by sensing the differential pressure between the outlet and the vent port, working on the piston and spring, opening or closing the inlet to the outlet port.

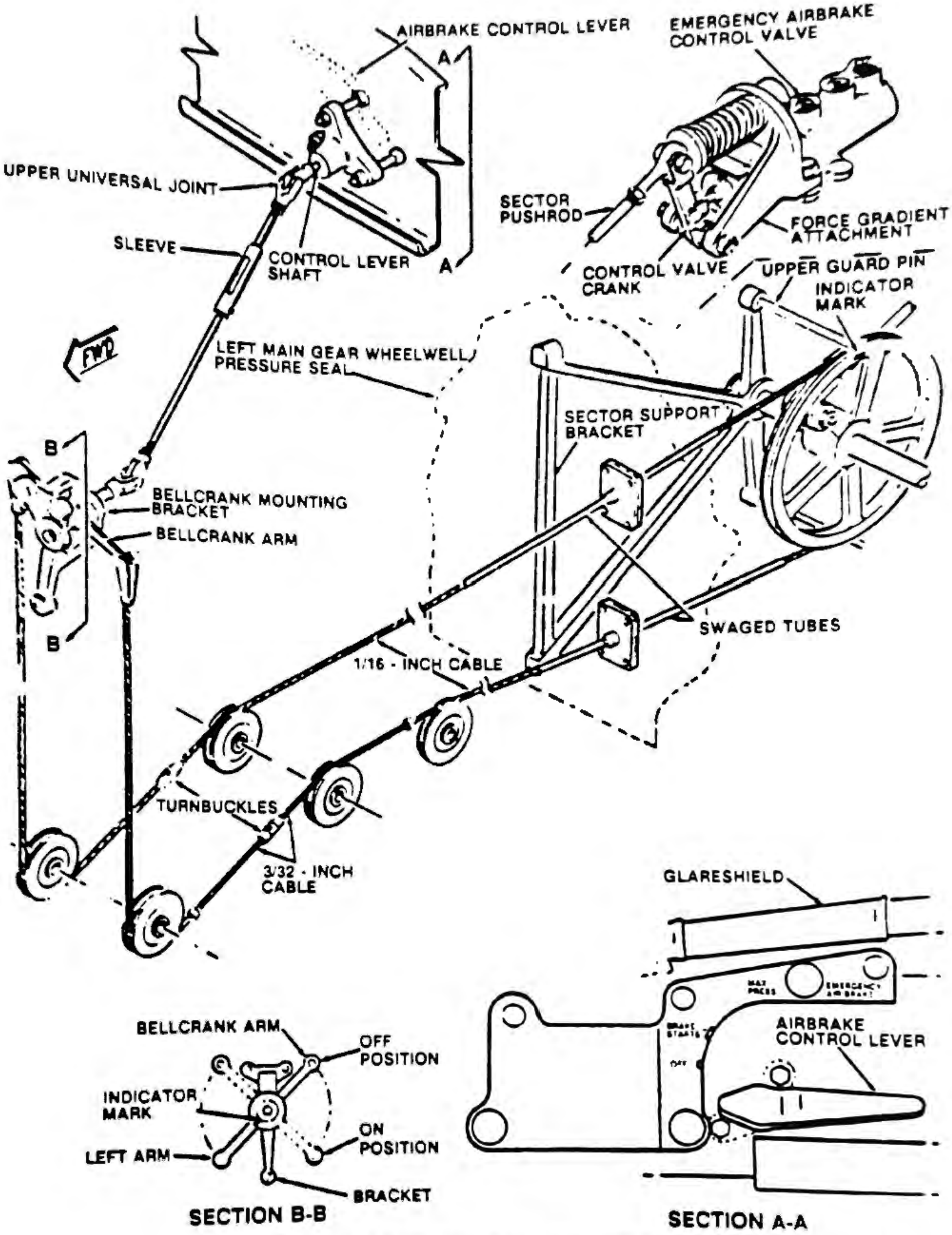
(5) By actuation of the lever to a lower pressure setting, the vent poppet will open and allow the outlet pressure to decrease to that setting and then close holding regulated pressure. With further actuation to the full open position, the vent poppet will remain open.

14. Emergency Airbrake Mechanical Control System - Description and Operation

A. General (See Figure 32-69)

(1) The emergency airbrake mechanical control system is a manually operated system which provides a means for actuating the wheel brake system pneumatically when hydraulic power is lost. The airbrake system consists of a control lever in the flight compartment, a 2-way closed cable circuit, a cable sector and pushrod assembly to actuate the airbrake control valve, located in the forward inboard section of the left main gear wheel well. The airbrake control lever is located on the glareshield instrument panel in the flight compartment.

(2) The airbrake control valve is fitted with a force gradient mechanism, which provides a limited amount of load feel to the airbrake controls. The force gradient permits some movement of the control lever before actual pressure is ported to the brakes. The point at which brake application begins is placarded as brake starts. Further clockwise rotation of the control lever increases brake pressure until the lever is at the position placarded maximum pressure.



AIRBRAKE MECHANICAL CONTROL SYSTEM FTX80168

Figure 32-69

B. Operation

(1) The airbrake system is manually operated through the mechanical control system. When the emergency airbrake control lever is turned clockwise, it rotates a shaft which actuates the bellcrank arms. The cables are connected to the arms and are moved as the arms move. The closed cable circuit extends aft to the left main gear wheel well and around another cable sector, which drives a pushrod to actuate the airbrake control valve. The pressure applied to the brakes is proportional to the torque applied to the control lever. Releasing the control lever allows the control valve to return to the off position, and drive the control lever to the off position.

15. Steering - Description and Operation

A. General (See Figure 32-70)

(1) The nosewheel steering system is a hydraulically actuated system which is mechanically controlled by a steering wheel, located on the left side of the flight compartment, and by the rudder pedals. The steering wheel controls 61 degrees of turning angle in either direction, and the rudder pedals control 15 degrees in either direction.

(2) The nosewheel steering mechanical control system consists of a steering wheel and cable drum assembly, a 2-way cable system, a pedal steering override mechanism, a followup differential mechanism, and a ground shift mechanism.

(3) The steering wheel cable drum is the terminus of the nosewheel steering cable system. One cable connects the steering wheel cable drum to the pedal steering override mechanism, and the other cable beginning at the pedal steering override mechanism, passes through the followup differential and terminates at the steering wheel cable drum.

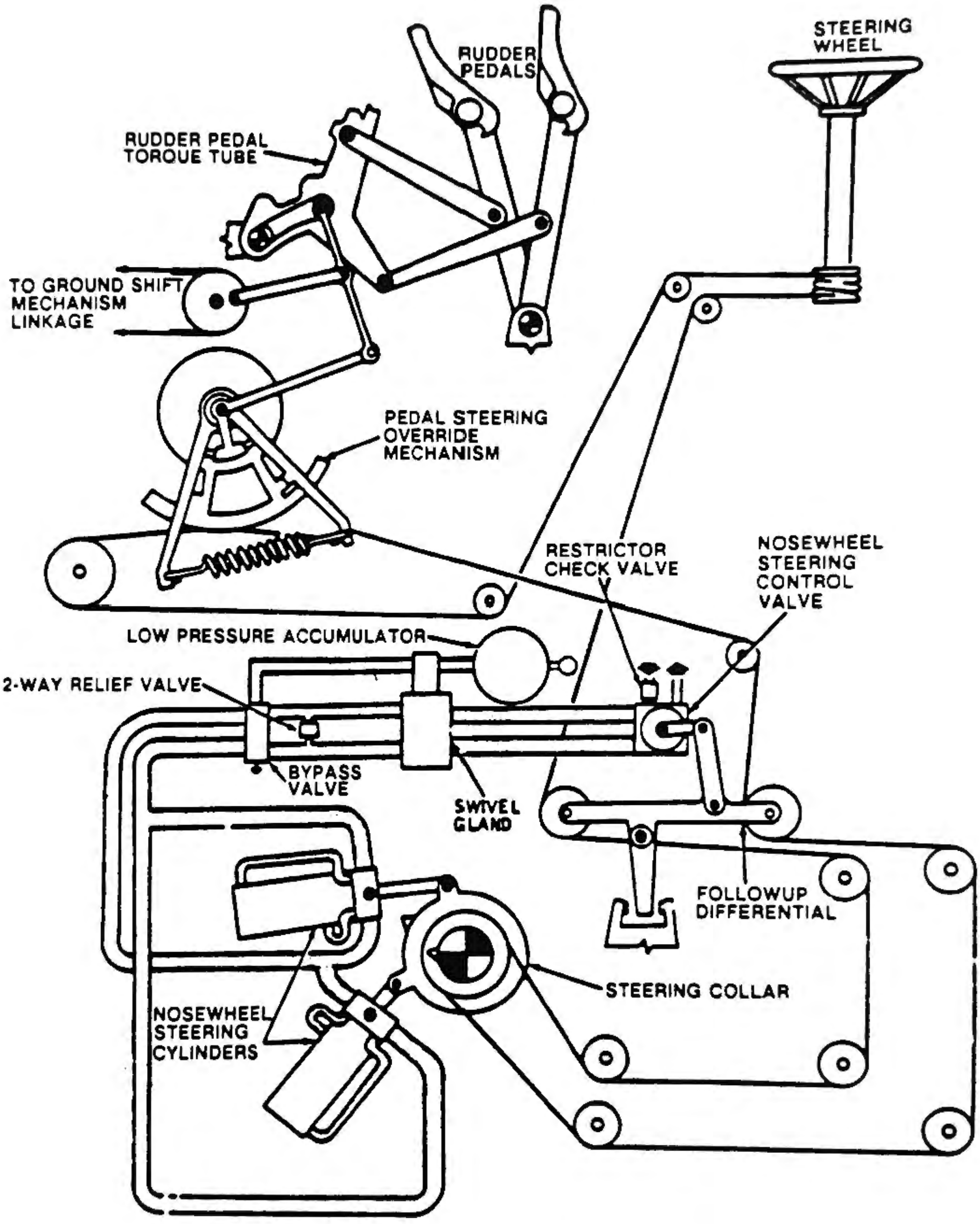
(4) The pedal steering override mechanism permits 15 degrees steering control in either direction through the use of the rudder pedals. This mechanism contains a locking cam and pushrod that locks out pedal steering during gear retraction. The followup differential mechanism transfers cable motion to the hydraulic control valves to steer the nosewheels.

(5) The ground shift mechanism positions the pedal steering override mechanism to permit use of the rudder pedals for limited nosewheel steering while the nose gear strut is compressed and to disengage or lock out rudder pedal steering when the nose gear strut is extended.

(6) The nosewheel steering hydraulic control system consists of a steering control valve, two steering cylinders, a relief valve, low-pressure accumulator, two reserve pressure accumulators, and a steering system bypass valve. The nosewheel steering control valve is mechanically connected to the nosewheel steering cable system through the linkage with the followup differential mechanism.

(7) The nosewheel steering hydraulic control valve receives hydraulic pressure from the landing gear control system down-pressure line, thereby permitting the system to be actuated only when the gear is extended. The low-pressure accumulator assists in preventing any tendency of the nosewheels to shimmy by supplying 150-psi hydraulic pressure to both steering cylinders when the steering control valve is in the neutral position. The low-pressure accumulator is also piped to the steering bypass valve to supply fluid, or to provide an outlet for excess fluid, in the steering cylinders as they are cycled during towing maneuvers.

(8) Two reserve pressure accumulators in the nosewheel steering system assure a supply of hydraulic pressure, after the gear is extended, for steering if the main hydraulic system pressure is lost.



NOSEWHEEL STEERING SYSTEM

FTX80170

Figure 32-70

16. Nosewheel Steering Mechanical Control System - Description and Operation

A. General (See Figure 32-71)

(1) The nosewheel steering mechanical control system consists of a 2-way, closed circuit cable system, a rudder pedal steering override mechanism, a nosewheel steering followup differential mechanism, and a steering wheel assembly. The system is manually operated by the steering wheel and/or the rudder pedals.

(2) The nosewheel steering system cables extend from the cable drum on the steering wheel shaft to the pedal steering override assembly, to the steering control valve followup differential assembly, and to the steering collar on the nose gear strut.

B. Steering Wheel and Drum (See Figure 32-72)

(1) The steering wheel is the primary control used to steer the airplane during ground maneuvers. The steering wheel is located on the forward end of the captain's console. When the indicator on the rim of the steering wheel is at the 12 o'clock position, the steering wheel is in the neutral position and the nosewheels are in the straight forward position.

(2) The wheel and drum assembly consists of a control wheel, wheel support assembly, bushing, tube, parking brake knob, spring and cable, retainer, and a cable drum assembly. The wheel is bolted to the support assembly by four bolts. The support assembly is riveted to the tube assembly. The tube assembly retains the spring, seat, and spring retainer ring for the parking brake knob, located in the center of the steering wheel. The cable drum is attached to the lower end of the steering wheel shaft.

(3) The steering wheel assembly is attached to the console by a support bracket. The shaft rides in a bearing at the upper support bracket and a bearing in the lower bracket. The lower bracket incorporates the support for the parking brake guide cable pulley and guard pins for the steering drum cables.

(3) A manual control arm is installed on the aft pulley of the followup differential and protrudes through a slot in the left bulkhead of the nosewheel well. The control arm is used to facilitate alignment of the nose gear torque links during reengagement of the nose gear torque link lockpin. A placard is mounted adjacent to the control arm and indicates the direction to move the arm for right or left steering.

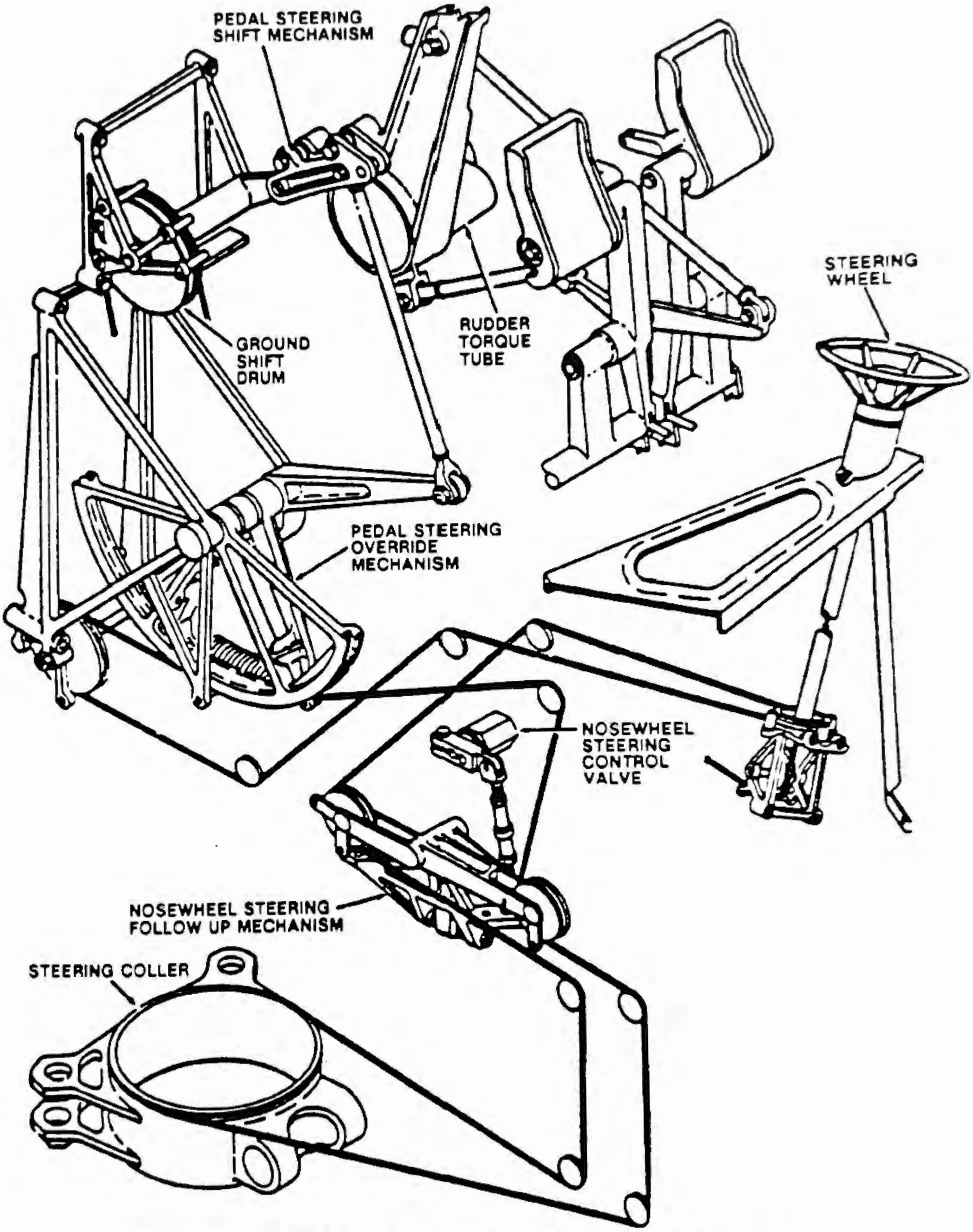
E. Operation

(1) When the ground shift mechanism has been shifted to the strut-compressed position, movement of the rudder pedals, either by depressing the pedals or by using the rudder trim system, moves the override mechanism and causes the nosewheel and the steering wheel to be displaced. Depressing either rudder pedal moves the pushrod connected to the ground shift mechanism. The pushrod, attached to the drive arm of the override mechanism, moves the override drive sector through the spring-loaded actuator arms. The sector moves, applying tension to the turning control cable and causing the followup differential to be moved. The followup differential opens the nosewheel steering control valve and directs pressure to the steering cylinders to produce up to 15 degrees of turning angle in the desired direction. The steering wheel in the flight compartment can be used to override the pedal steering at any time due to the spring-loaded connection in the override mechanism. When the steering wheel moves the cable to a position in excess of the maximum pedal steering movement, the override sector continues to move. This stretches the spring and permits the override sector to move the applicable spring-loaded actuator arm away from the drive arm.

17. Nosewheel Steering Hydraulic Control System - Description and Operation

A. General (See Figure 32-75)

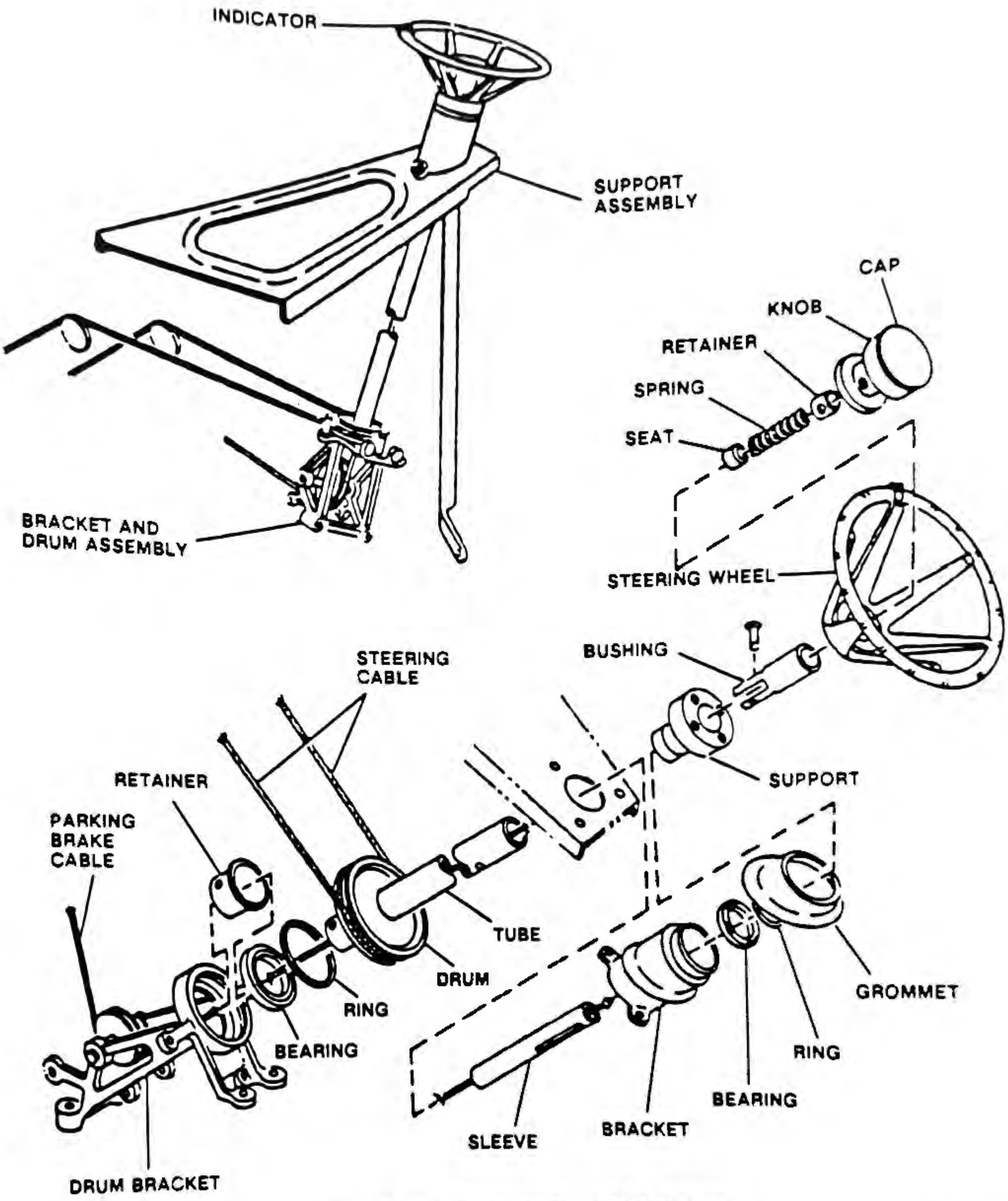
(1) The nosewheel steering hydraulic control system consists of a control valve, two steering cylinders, two swivel glands, four elbow orifice valves, a relief valve and bleed valve in the low-pressure side of the system, and a low-pressure accumulator, and relief valve, two reserve pressure accumulators, and a reserve pressure shutoff valve.


PEDAL STEERING SHIFT MECHANISM
STEERING WHEEL
GROUND SHIFT DRUM
RUDDER TORQUE TUBE
PEDAL STEERING OVERRIDE MECHANISM
NOSEWHEEL STEERING CONTROL VALVE
NOSEWHEEL STEERING FOLLOW UP MECHANISM
STEERING COLLER

NOSEWHEEL STEERING MECHANICAL CONTROL SYSTEM

FTX80171

Figure 32-71



STEERING WHEEL AND DRUM

FTX80172

Figure 32-72

C. Pedal Steering Override Mechanism (See Figure 32-73)

(1) The pedal steering override mechanism is the connecting assembly that links the rudder pedal steering to the normal (steering wheel) mechanical control system. The rudder pedal linkage provides a maximum of 15 degrees steering control to either side of neutral. The mechanism is spring loaded to the neutral position and returns the steering wheel to neutral from any degree of rotation.

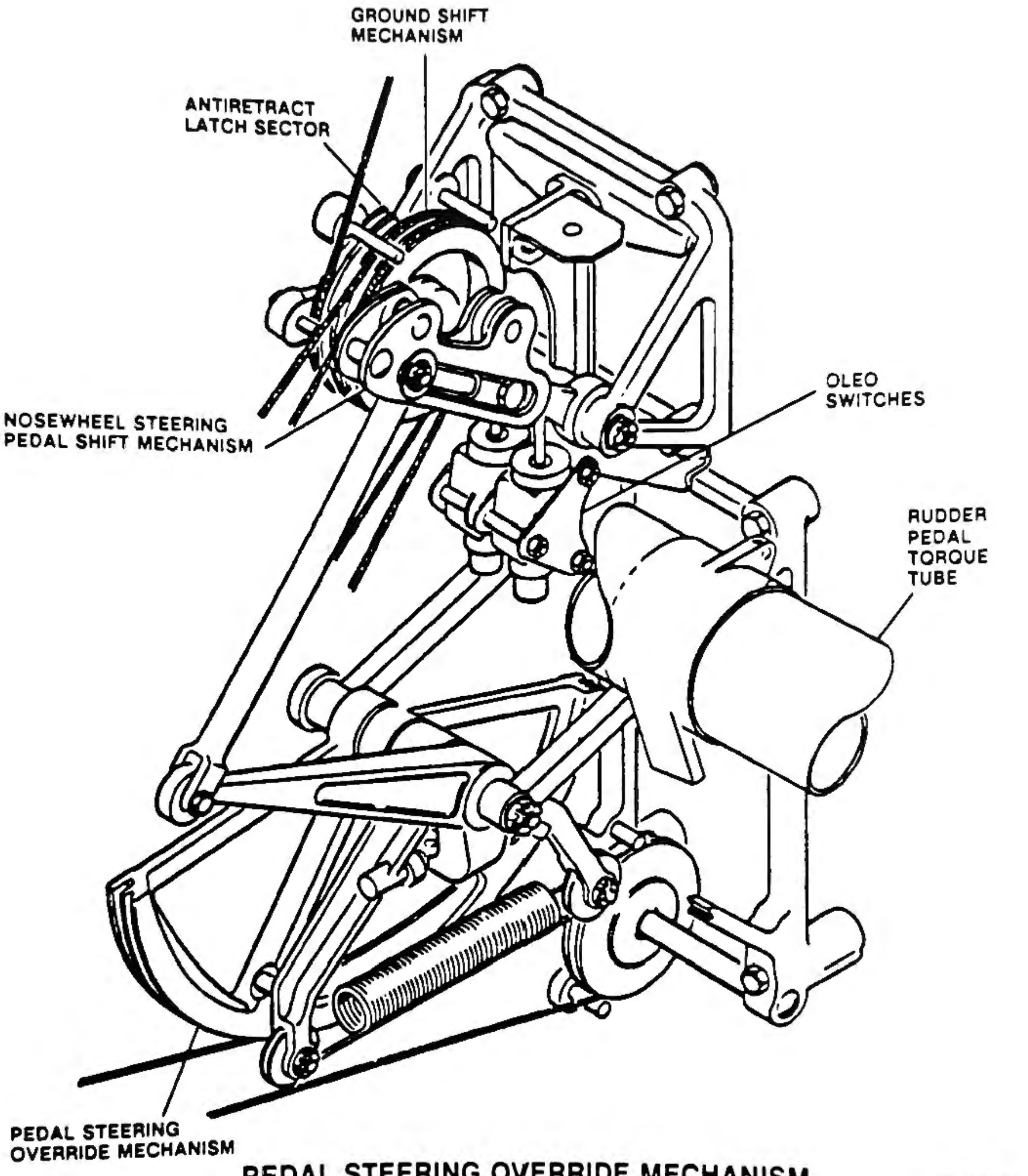
(2) The override mechanism consists of a bracket in which the following assemblies are mounted: a sector, drive arm, two spring-loaded actuator arms with a spring between them, a phenolic rub strip to protect the ground shift cable, and a common support axle.

(3) The sector and two spring-loaded arms have adjustable stops to adjust the mechanism to zero lash. The drive arm is attached to the pushrod which is attached to the shift drum and cam follower.

D. Nosewheel Steering Followup Differential Mechanism (See Figure 32-74)

(1) The nosewheel steering followup differential mechanism transmits cable motion through linkage to actuate the steering control valve. The assembly also serves as a followup to return the control valve to the neutral position when the desired angle of nosewheel turn has been reached. The differential assembly is bearing mounted to the support bracket, off center to the beam centerline, and is free to rotate in two directions. The control valve linkage is attached to the link attach arm near the aft end fitting of the differential beam. A pulley is mounted on each end of the beam, and the steering cables are routed through the pulleys.

(2) As the steering wheel is displaced, tension is increased on the turn cable. This tension unbalances the differential followup on its pivot axis and, through linkage, opens the steering control valve. As the nosewheels turn, tension on the turning cable is relieved, allowing the differential to return the control valve to neutral position.



PEDAL STEERING OVERRIDE MECHANISM

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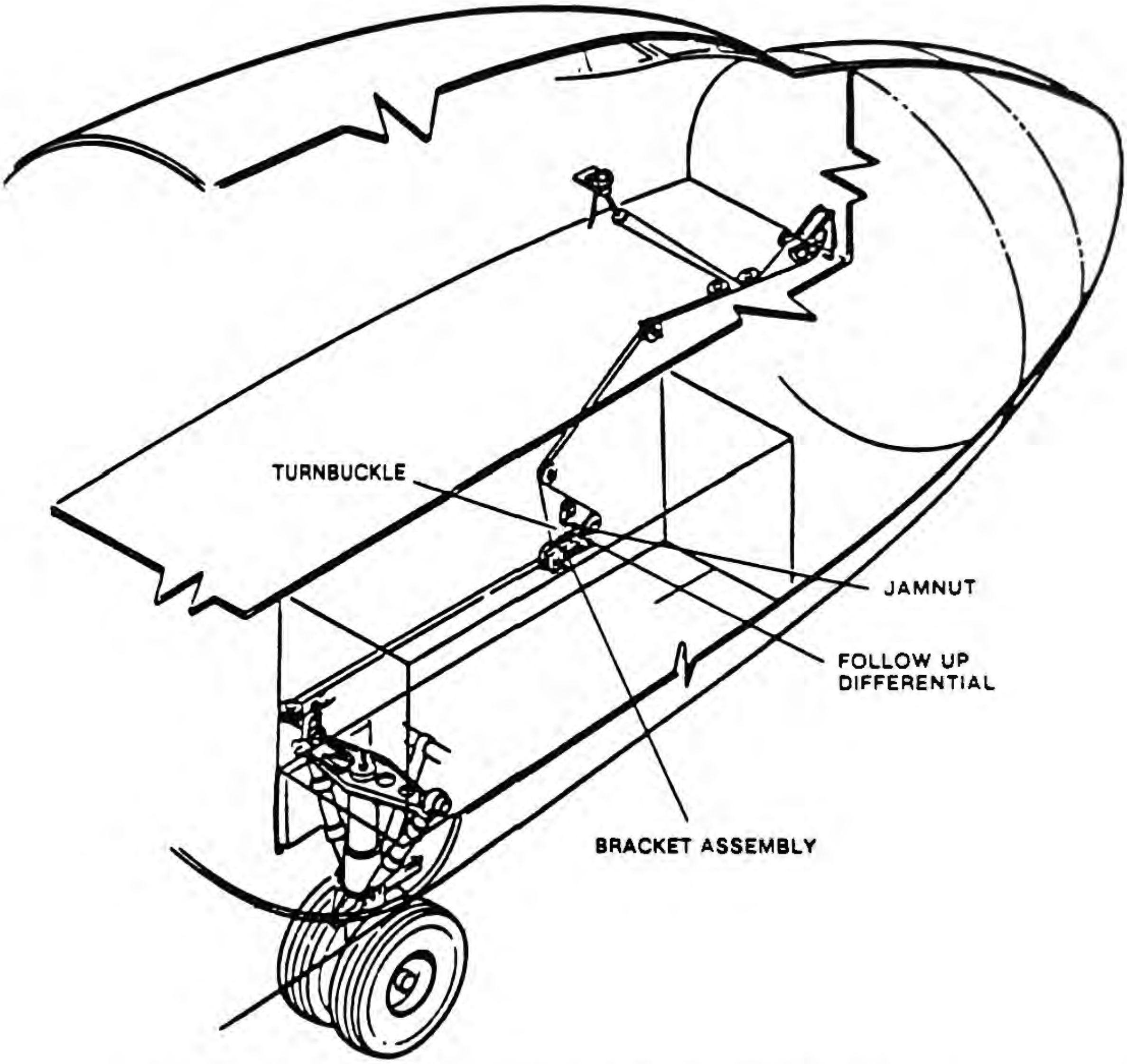
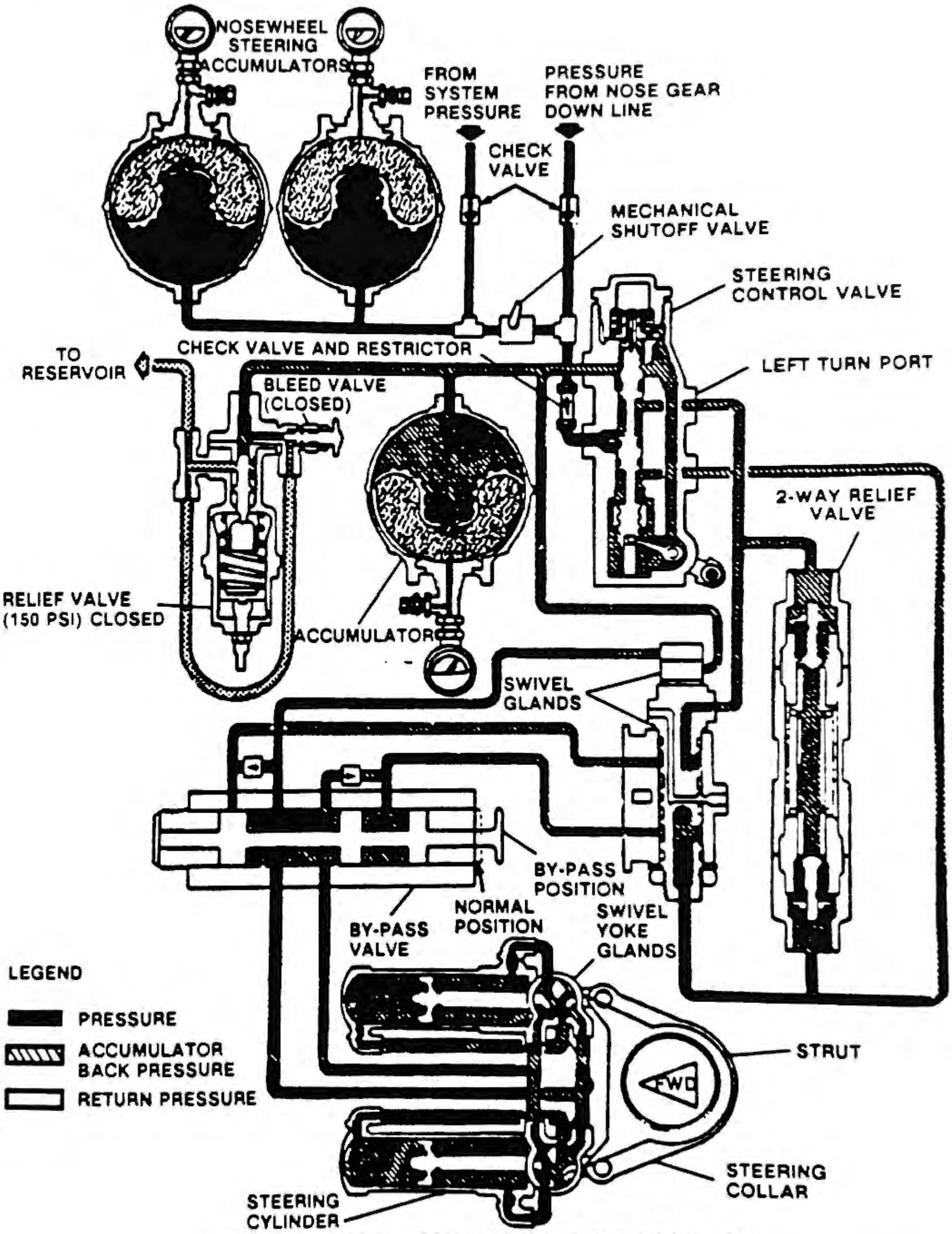
Figure 32-73



NOSEWHEEL STEERING FOLLOW UP DIFFERENTIAL FTX80174

Figure 32-74



NOSEWHEEL STEERING HYDRAULIC CONTROL SYSTEM -- SCHEMATIC

FTX80175

Figure 32-75

(2) The steering control valve is mechanically linked to the nosewheel steering cable system through linkage with the followup differential mechanism. The control valve receives hydraulic pressure from the nose gear control valve down-pressure line and operates only when the gear is extended.

(3) The nosewheel steering system is supplemented by two reserve pressure accumulators and a mechanically actuated shutoff valve to assure a reserve source of hydraulic pressure for limited steering, if the main system is lost.

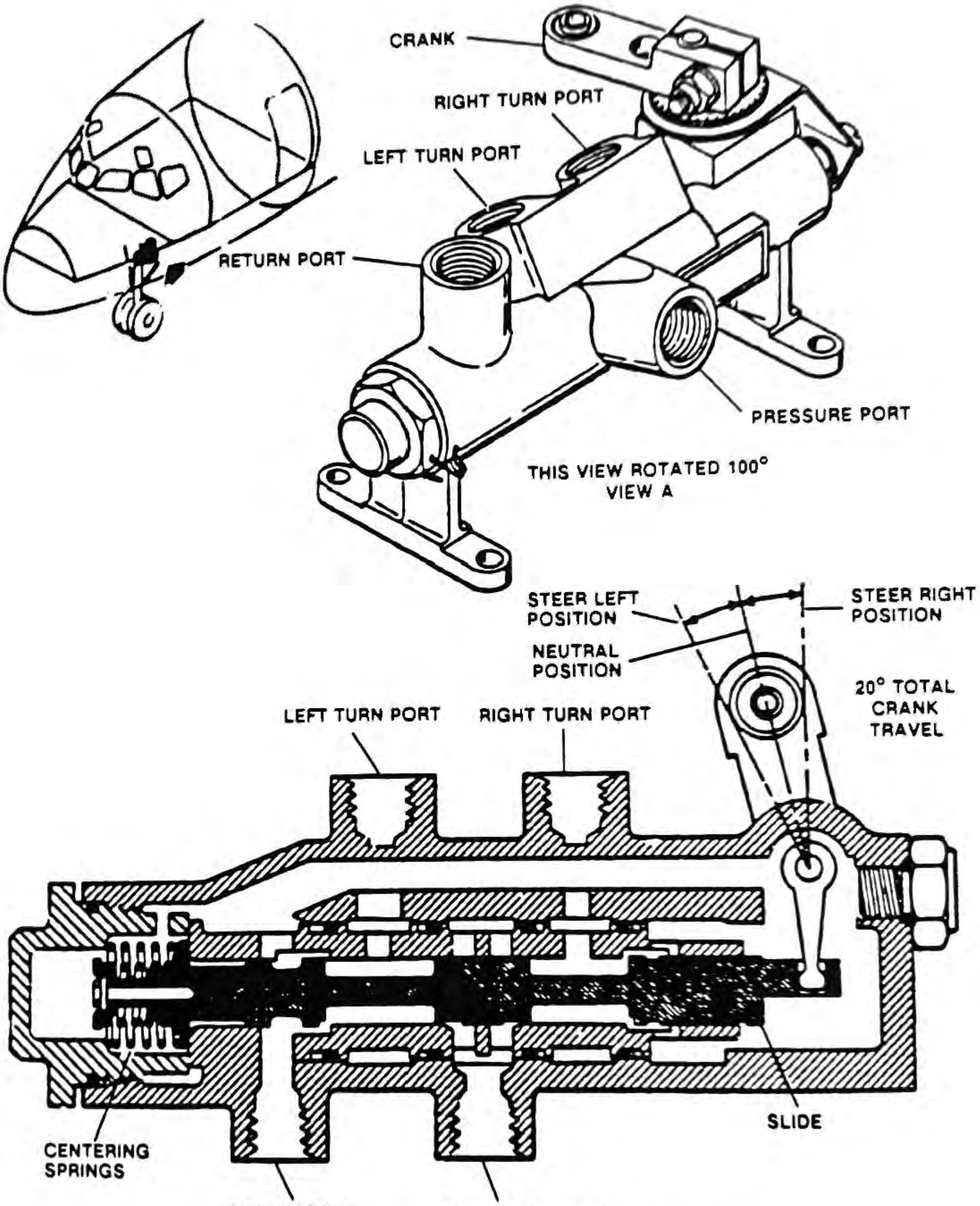
(4) The low-pressure accumulator supplies back pressure to the steering cylinders to maintain neutral position, when the control valve is in neutral position, and to prevent the nosewheels from drifting or shimmying. A check valve in the low-pressure line prevents back flow to the low-pressure accumulator from the bypass valve.

B. Nosewheel Steering Hydraulic Control Valve (See Figure 32-76)

(1) The nosewheel steering control valve is a mechanically actuated, 3-position, slide-type hydraulic valve which is spring loaded to the neutral position. Internally, the valve contains a lapped slide assembly, two centering springs, packings and seals, and an operating crank.

C. Nosewheel Steering Cylinders (See Figure 32-77)

(1) The nosewheel steering cylinders are 2-way operating hydraulic cylinders, used to turn the nosewheels. Each cylinder consists of a cylinder and piston assembly with O-ring packings. The two steering cylinders are installed on the upper and lower support brackets of the nose gear shock strut by two trunnion pins. The upper trunnion pin is in the shaft portion of the yoke gland shaft, and the lower pin is a swivel pin. The swivel pin and gland shaft are retained by lockbolts. The piston rods have integral rod ends that attach to the steering collar, and require no adjustment.



NOSEWHEEL STEERING HYDRAULIC CONTROL VALVE -- CUTAWAY

Figure 32-76

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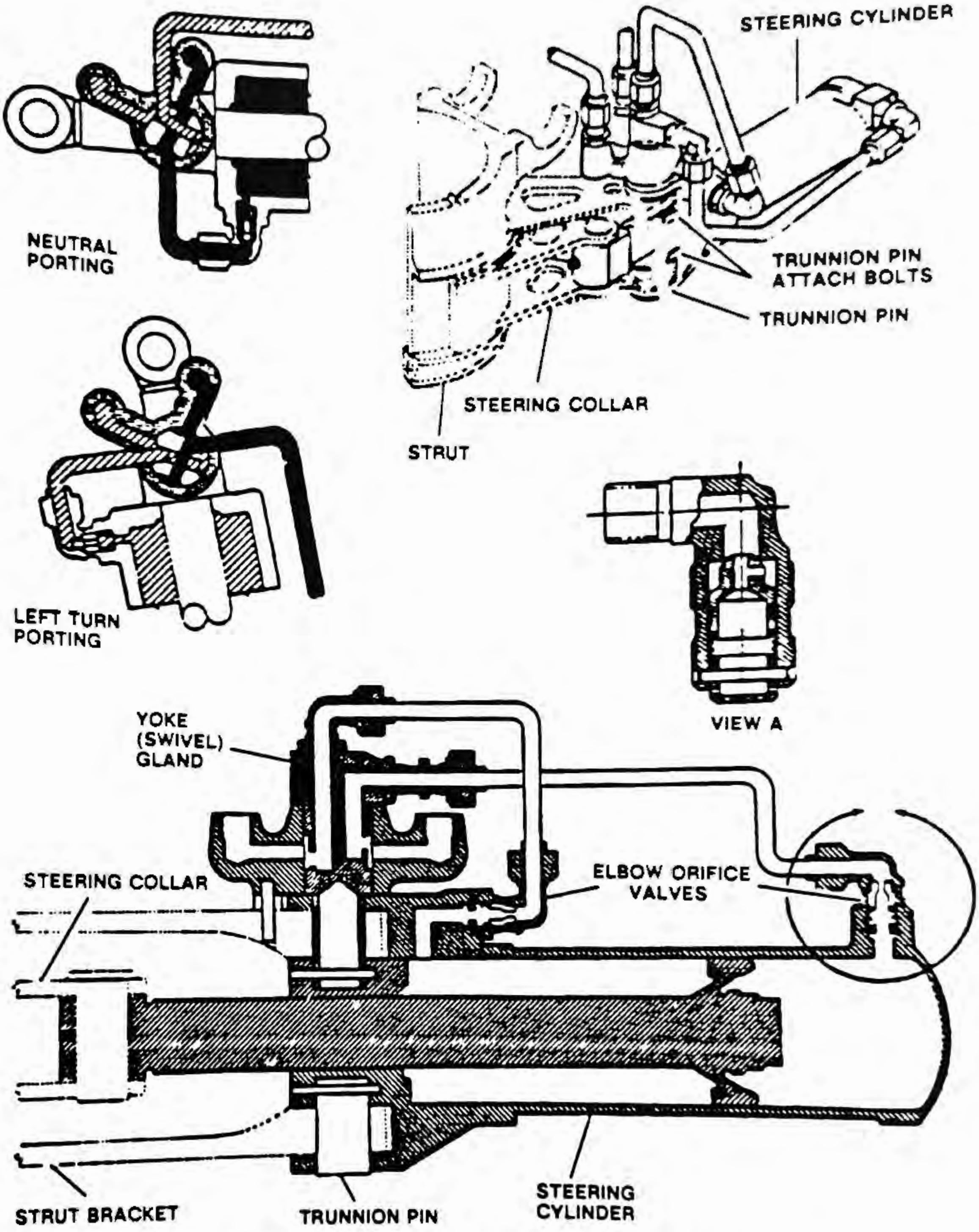


NOSEWHEEL STEERING CYLINDERS, YOKE GLANDS, AND ORIFICE VALVES -- CUTAWAY

FTX80177

Figure 32-77

D. Nosewheel Steering Cylinder Yoke Glands (See Figure 32-77)

(1) The nosewheel steering cylinder yoke glands are flexible connections for the hydraulic lines to the steering cylinders. The yoke glands also function as directional control valves as the nosewheels rotate left and right, porting fluid to the head, rod, or neutral positions as required. The gland assembly is mounted to each steering cylinder upper support bracket on the forward side of the nose gear shock strut. The body of each gland is anchored to the upper steering cylinder support bracket. The gland shaft pivots with the steering cylinders and directs hydraulic pressure to whichever end of the cylinder necessary to control the direction of nosewheel turning.

(2) The yoke gland assembly consists of a body, a shaft, O-rings, and backup rings. The shaft and body are lapped assembly. The hydraulic pressure and return lines from the nosewheel steering control valve route through the bypass valve and to the body of the yoke gland, and the lines for operating the steering cylinders are connected to the shaft. The shaft is also the upper trunnion pin for the steering cylinder.

E. Steering Cylinder Elbow Orifice Valves (See Figure 32-77)

(1) The elbow orifice valve assemblies consist of a body, a poppet valve, a spring, a snap ring, and a filter. Elbow orifice valves are installed in the steering cylinder ports and are the connections for the hydraulic lines from the yoke glands. Elbow orifice valves permit free flow of hydraulic fluid into the steering cylinders, but restrict the outflow of fluid. The purpose of the valve is to provide (along with the steering system low-pressure accumulator) a constant back pressure against the cylinder pistons to prevent any tendency of the nosewheels to shimmy. The filter, installed in the end of the elbow adjacent to the poppet valve, prevents contaminants from clogging the restrictor orifice.

F. Nosewheel Steering System Relief Valve and Bleeder Valve (See Figure 32-78)

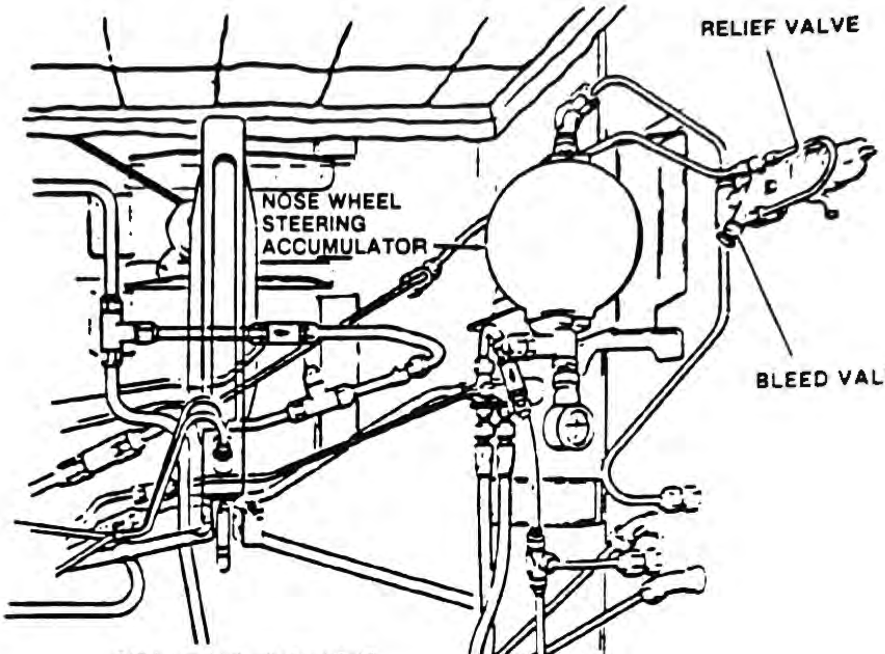
(1) The nosewheel steering relief valve is a spring-loaded hydraulic valve used to maintain a back pressure of 150 psi in the steering system accumulator, and in the steering cylinders to hold the cylinders in neutral position when the control valve is in the neutral position and to prevent nosewheel shimmy. The relief valve consists of a valve body, a housing, lap assembly, spring guide, pressure adjuster screw and nut, and packings.

(2) The bleed valve consists of a body, a needle valve, control knob, and a locknut. The bleed valve is installed on the relief valve, is used to bypass the relief valve, and allows hydraulic pressure in the accumulator and steering cylinders to be ported to the hydraulic system return. The bleed valve is opened to permit initial air pressure of the accumulator to be read on the gauge.

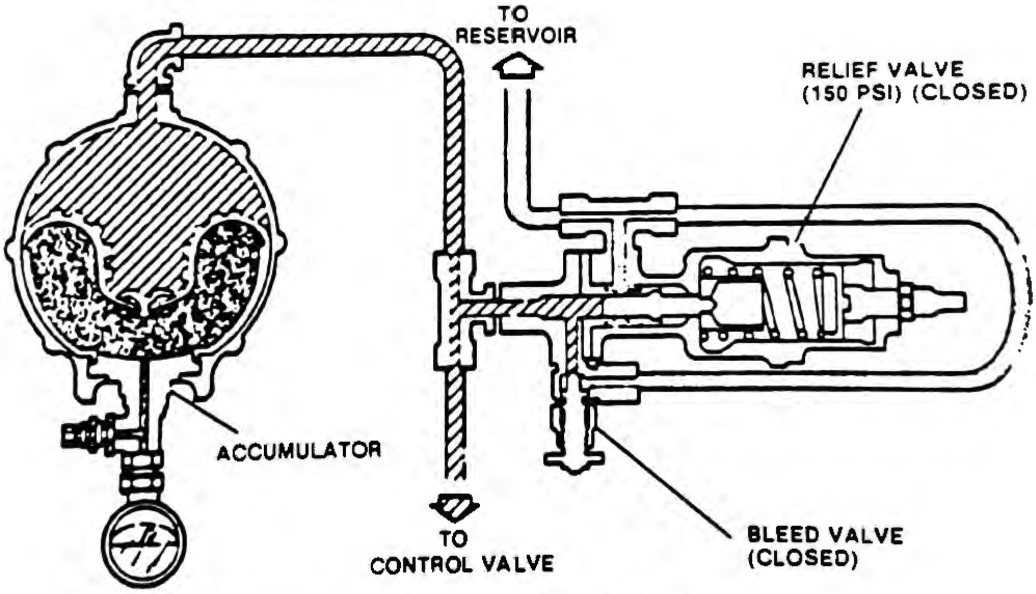
G. Nosewheel Steering System Low-Pressure Accumulator (See Figure 32-78)

(1) The nosewheel steering system low-pressure accumulator is a standard, spherical, steel body with an air filler valve and a direct reading pressure gauge. The accumulator is teed into the nosewheel steering return line and is installed in the aft left side of the nosewheel well. The body is approximately 5 inches in diameter and is divided into two separate chambers by a synthetic rubber diaphragm. The lower chamber is inflated with an initial air charge of 50 psi. The fluid capacity in the upper chamber of the accumulator is 60 cubic inches. A banjo-type fitting is connected to the bottom of the accumulator by a hydraulic bolt. A high-pressure air filler valve is installed in the banjo fitting and the bolt serves as the connection for the direct reading air pressure gauge. The gauge registers from 0 to 300 psi in the 100-psi increments.

(2) The nosewheel steering low-pressure accumulator assists in preventing nosewheel shimmy by supplying 150-psi hydraulic back pressure to the cylinders return system when the steering control valve is in neutral position. The low-pressure accumulator also connects to the bypass valve to supply fluid to the steering cylinders as needed, due to the cycling action of the cylinder pistons during towing maneuvers.



NOSE GEAR WHEELWELL
VIEW LOOKING AFT



NOSEWHEEL STEERING SYSTEM RELIEF VALVE,
BLEEDER VALVE AND ACCUMULATOR -- CUTAWAY FTX80178

Figure 32-78

H. Nosewheel Steering System Reserve Pressure Accumulators

(1) The nosewheel steering system reserve pressure accumulators are spherical, welded-steel fluid and air containers. They are used to supply a limited amount of hydraulic pressure to the steering cylinders after the gear is down and the nose gear strut is compressed, if main hydraulic system pressure is lost. An air filler valve and pressure gauge is installed in each accumulator. The air chamber is pressurized to 500 psi with dry nitrogen, and the fluid chamber accommodates a total of 330 cubic inches of hydraulic fluid at 3000 psi. The reserve accumulators are pressurized directly from the main hydraulic power system pressure line and are isolated from the main system by a 1-way check valve to prevent bleed back into the main system when system pressure is removed.

I. Nosewheel Steering System Reserve Pressure Shutoff Valve

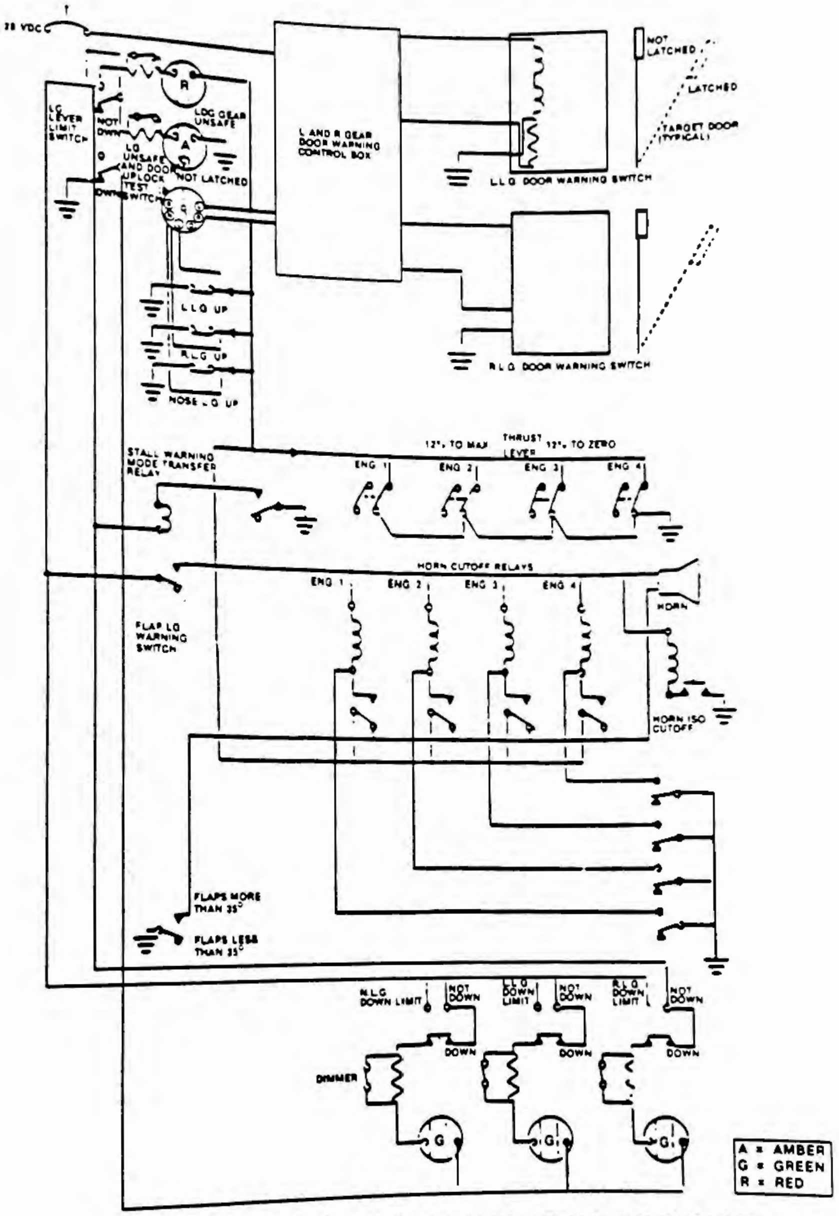
(1) The nosewheel steering system reserve pressure accumulators are isolated from the steering system by a mechanically actuated shutoff valve when the nose gear is in the up position. The shutoff valve prevents premature bleedoff of accumulator pressure through the main system and assures a source of hydraulic pressure after the nose gear strut is compressed for use in the steering system if main hydraulic system pressure is lost.

(2) The shutoff valve is mechanically actuated by linkage attached to the ground shift mechanism actuating rod. When the nose gear strut is compressed approximately 10 inches, the ground shift mechanism linkage moves the shutoff valve arm to the open position. With the valve open, reserve accumulator pressure is ported to the nosewheel steering control valve for limited steering control.

J. Operation (See Figures 32-79, 32-80 & 32-81)

(1) The operation of the nosewheel steering hydraulic system is mechanically controlled by the steering wheel and/or the rudder pedals in the flight compartment.

(2) When the steering wheel is turned, the steering control valve is displaced by the followup differential mechanism through the steering cable system. The control valve opens and ports pressure from the down-pressure side of the nose gear control valve through the swivel



POSITION AND WARNING SIMPLIFIED SCHEMATIC

FTX80182

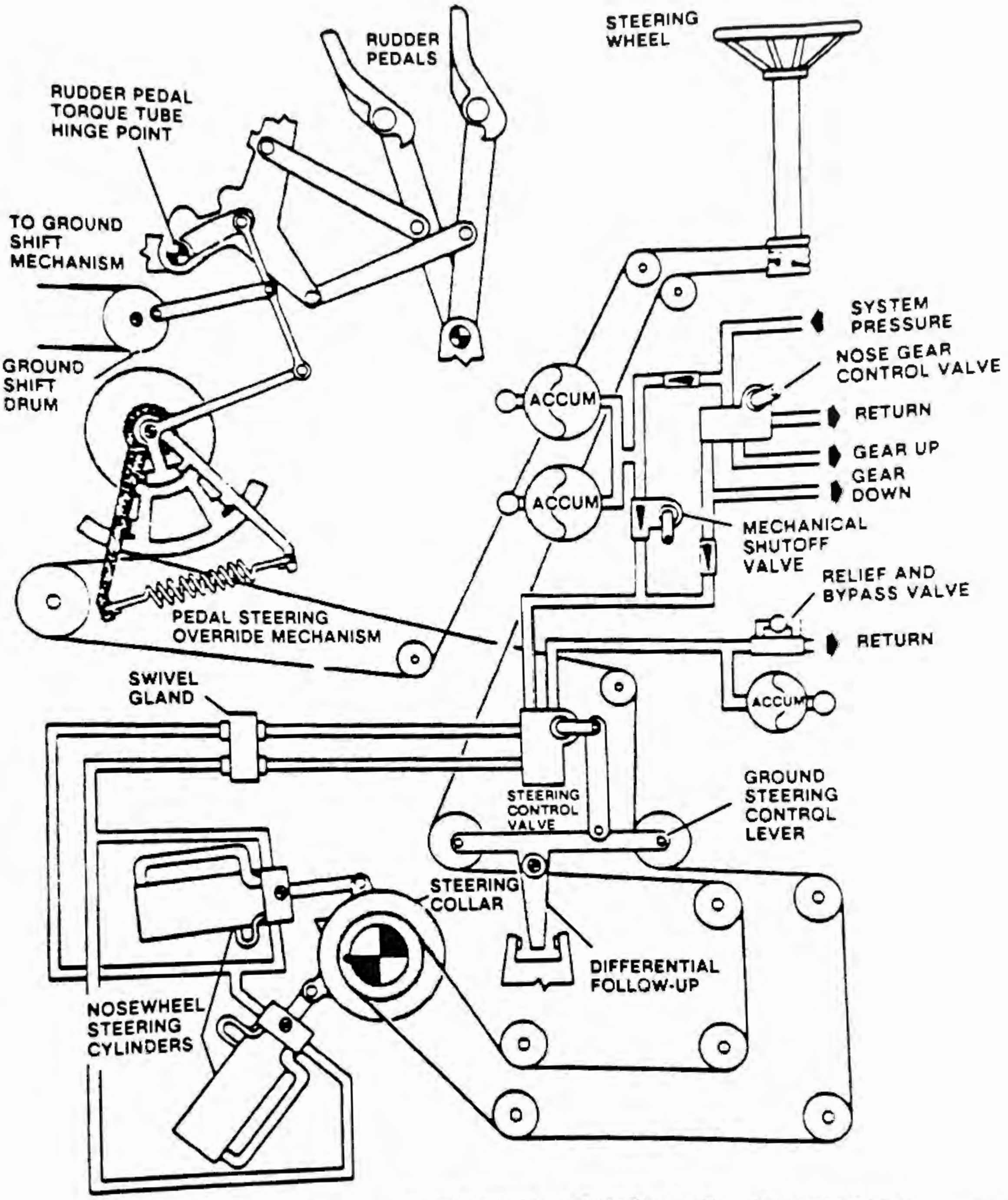
Figure 32-82

gland to the yoke glands. The yoke glands on the steering cylinders direct pressure through the orifice valves to the piston head side of one cylinder and to the rod side of the other cylinder (see Figure 32-80). One cylinder piston is extending and imparting a pushing force on one side of the steering collar, and the other cylinder is retracting, imparting a pulling force on the opposite side of the steering collar. The steering cylinder, attached to the nose gear shock strut, pivots as the nosewheels turn.

(3) When the retracting (pulling) cylinder moves past the on-center position, the steering yoke assembly shuts off and then redirects pressure from the rod end of the piston to the head end of the piston. This causes a reversal of the cylinder action (from a pulling to a pushing action) and continues the rotation of the wheels in the same turning direction. As the nosewheels turn, tension on the steering control cables is relieved and the followup differential mechanism returns the steering control valve to the neutral position when the nosewheels reach the desired degree of turn. This hydraulically locks the steering cylinders and holds the nosewheels in the selected position.

(4) Anytime the steering control valve is in the neutral position, the low-pressure accumulator and relief valve hold 150-psi back pressure on both sides of the steering cylinder pistons, and, in conjunction with the restrictor valves, prevent the nosewheels from shimmying or drifting.

(5) The two reserve pressure accumulators assure a limited supply of pressure to the steering system in the event of a hydraulic power failure. The mechanically actuated shutoff valve is moved to the open position by linkage connected to the ground shift mechanism when the gear is extended and the shock strut is compressed.

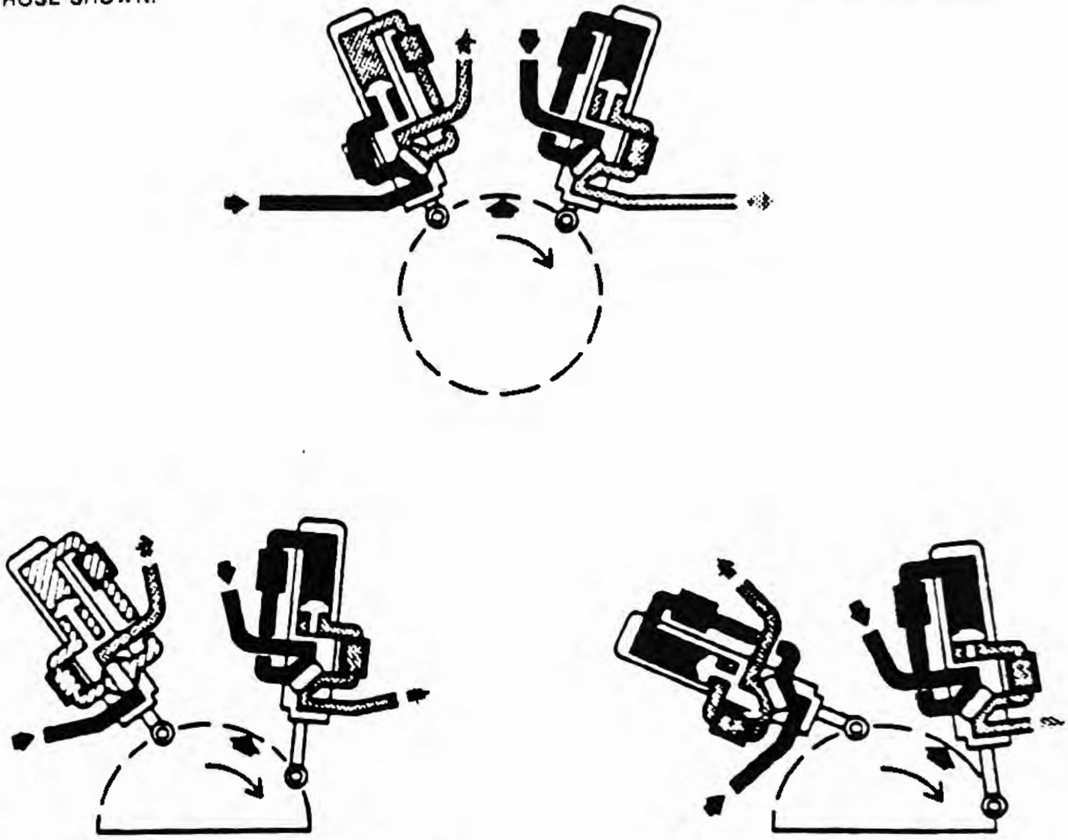


NOSEWHEEL STEERING SYSTEM -- SIMPLIFIED SCHEMATIC FTX80181

Figure 32-79

NOTE:
FLOW AND POSITIONS FOR LEFT TURN WILL BE THE REVERSE OF THOSE SHOWN.

1. POSITION SHOWN IS FOR NOSE WHEEL STRAIGHT FORWARD AT BEGINNING OF RIGHT TURN. LEFT CYLINDER PULLING, RIGHT CYLINDER PUSHING.



2. POSITION SHOWN IS FOR NOSE WHEEL TURNING RIGHT. LEFT CYLINDER ON CENTER, RIGHT CYLINDER PUSHING.

3. POSITION SHOWN IS FOR NOSE WHEEL IN MAXIMUM RIGHT TURN. LEFT CYLINDER PAST CENTER, BOTH CYLINDERS PUSHING.

LEGEND

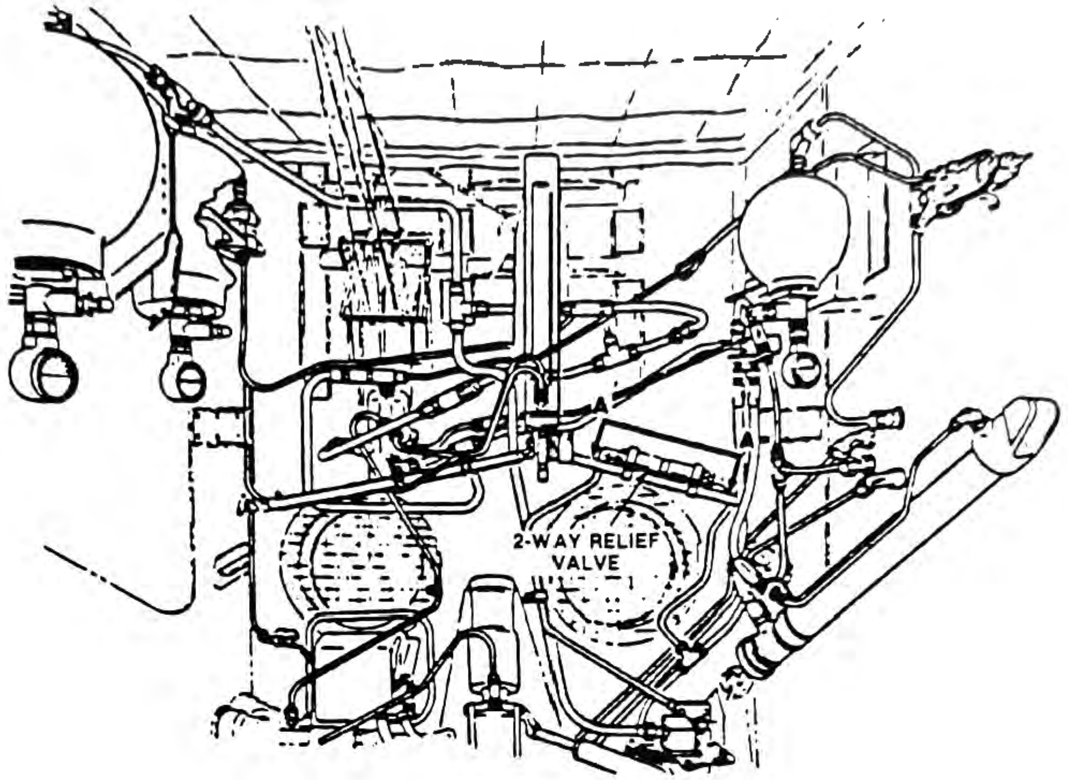
■ PRESSURE

▨ STATIC PRESSURE

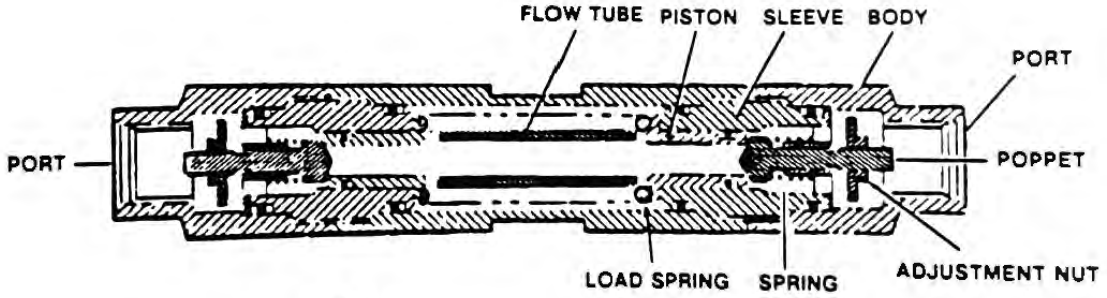
▒ ACCUMULATOR BACK PRESSURE

NOSEWHEEL STEERING SYSTEM -- CYLINDER POSITIONS FTX80180

Figure 32-80



NOSEWHEEL WELL
VIEW LOOKING AFT



VIEW A-A
CUT AWAY

NOTE:
CALLOUTS TYPICAL FOR
BOTH ENDS OF VALVE

NOSEWHEEL STEERING SYSTEM TWO-WAY RELIEF VALVE -- CUTAWAY

FTX80179

Figure 32-81

18. Position and Warning - Description and Operation

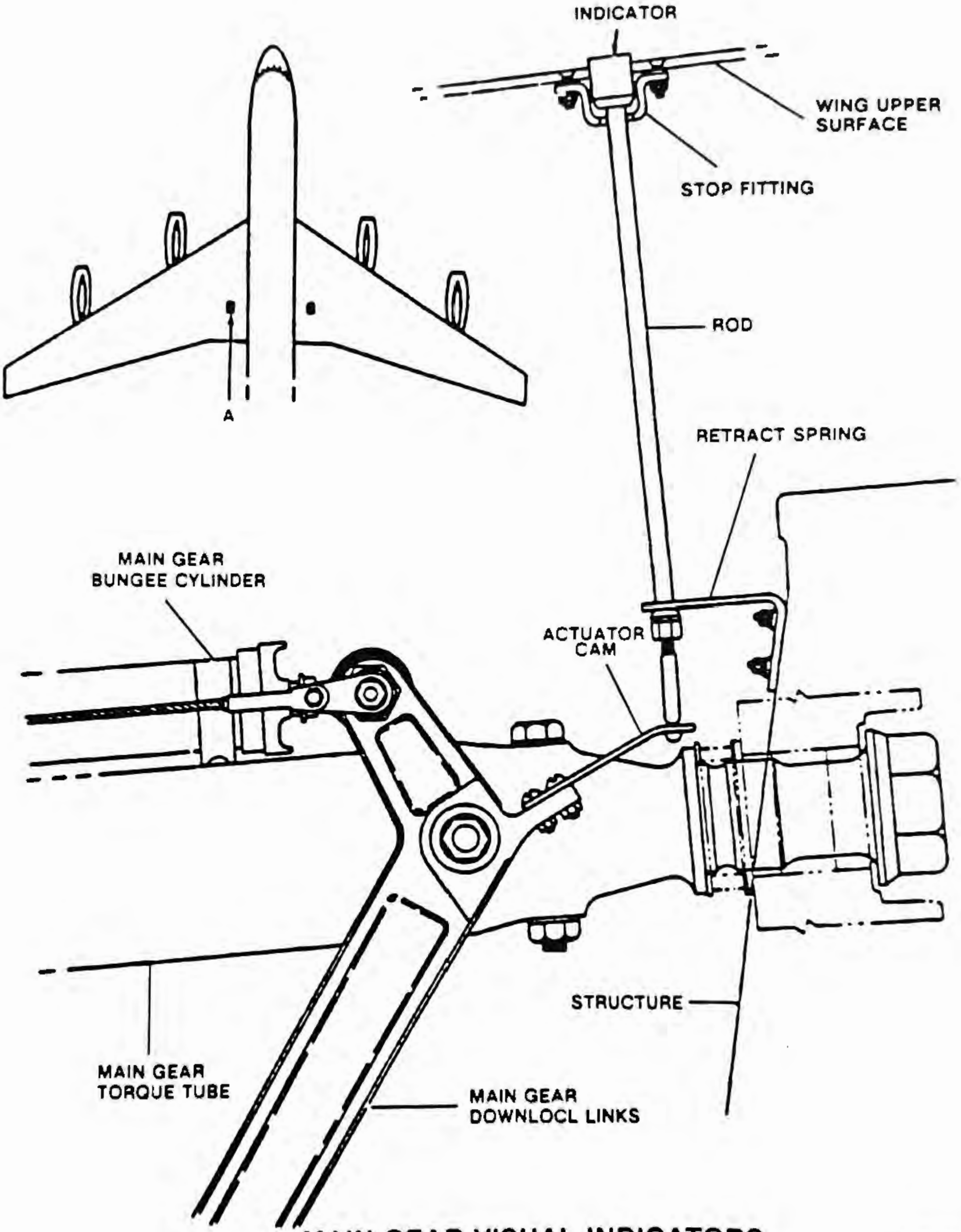
A. General (See Figure 32-82)

(1) The landing gear position and warning system provides an audible and visual indication of the position of the landing gear and main gear doors. The green gear-safe lights, and the red gear-unsafe lights are grouped on the lower section of the landing gear control lever panel. The lights are dimmable. The landing gear warning horn indicates audibly that the landing gear is in an unsafe condition for landing. For troubleshooting when the red LDG GEAR UNSAFE light is on, a LDG GEAR & DOOR LATCHING selector switch and an amber NOT LATCHED light are installed on the F/E Instrument Panel.

(2) The green lights are controlled by the downlock limit switches on the corresponding landing gear and by the landing gear control lever limit switch. The red lights are controlled by the landing gear control lever limit switch, landing gear up limit switches, engine throttle limit switches, main gear door-closed proximity switches, and the landing gear downlock limit switches. The horn is controlled by the throttle limit switches, landing gear downlock limit switches, landing gear control lever limit switch, flap limit switch, horn cutoff switch, warning horn cutoff relays, and the horn isolation relay.

B. Main Gear Visual Downlock Indicator (See Figure 32-83)

(1) The main gear visual downlock indicator is a mechanically actuated indicator button used to show when the downlock links of the main gear are actuated overcenter in a safe gear down position. The indicator assembly consists of an indicator button, stop fitting, retract spring, and actuator cam. The indicator button is orange in color and is approximately 1 inch long by 1 inch in diameter. The indicator button is attached to a rod which passes through the stop fitting and the retract spring. The retract spring is installed on the auxiliary spar and positions the lower end of the rod. An adjustable tappet is installed in the end of the rod and is secured by a beveled washer and nut. The stop fitting is hat shaped and is installed on the inner surface of the wing plating. The stop is shimmed with washers to position the indicator button flush with the wing surface when the gear is not locked in down position. The indicator is spring loaded to the retract position. The actuating cam is installed on the upper end of the forward set of downlock links.



MAIN GEAR VISUAL INDICATORS

FTX80183

Figure 32-83

O. Landing Gear Warning Horn Cutoff Switch

(1) The landing gear warning horn cutoff switch is a press-type, hole-mounted switch, located on the glareshield instrument panel. When the switch is depressed, it energizes the isolation relay and energizes the horn cutoff relays. Releasing the cutoff switch deenergizes the isolation relay. This allows all horn cutoff relays to deenergize except when any throttle is in a position from idle stop to approximately 7 degrees from idle stop.

(2) A switch, mounted inside the captain's control pedestal, is actuated by an adjustable, serrated cam attached to the wing flap handle. When the flaps are extended 35 degrees or more, with the landing gear retracted, the switch completes the circuit to the warning horn through the landing gear warning system. The completed circuit overrides the warning horn silencing switch and sounds the warning horn regardless of the throttle position.

P. Operation

(1) The green lights come on when the corresponding landing gear is down and locked, and the landing gear control lever is in the down detent position.

(2) The red lights come on when any of the following conditions exist:

(a) Airplane is on the ground and the landing gear control lever is moved out of the down detent.

(b) In flight, all times during landing gear travel.

(c) In flight, landing gear control lever in down detent and all landing gears not down and locked.

(d) On takeoff, after retraction, if all gears are not up or doors are not closed.

(e) Anytime landing gear is not down and locked, and any one of the four engine throttles is moved back into a position approximately 7 degrees from idle stop.

C. Nose Gear Visual Downlock Indicator (See Figure 32-84)

(1) A simple means is provided to permit the flight crew to visually check the nose gear overcenter linkage for downlock position, if the position indicating electrical system malfunctions. This consists of an access door, an inspection tube, a spotlight, a painted marking on the nose gear overcenter linkage.

(2) The access door is a 3 x 3-inch plate, located in the passageway floor aft of the electrical power center aft equipment panel in the flight compartment. The tube is located under this door and is normally capped with a vacuum bottle cork. It can be removed when the airplane is below 10,000 feet altitude (2-psi cabin pressure differential). The nose gear overcenter linkage is marked with painted stripes to indicate locked position. A spotlight may be used to view the indicator markings on the links. The switch for the spotlight is located behind an access door in the lower section of the aft equipment panel.

D. Main Gear Downlock Limit Switch (See Figure 32-85)

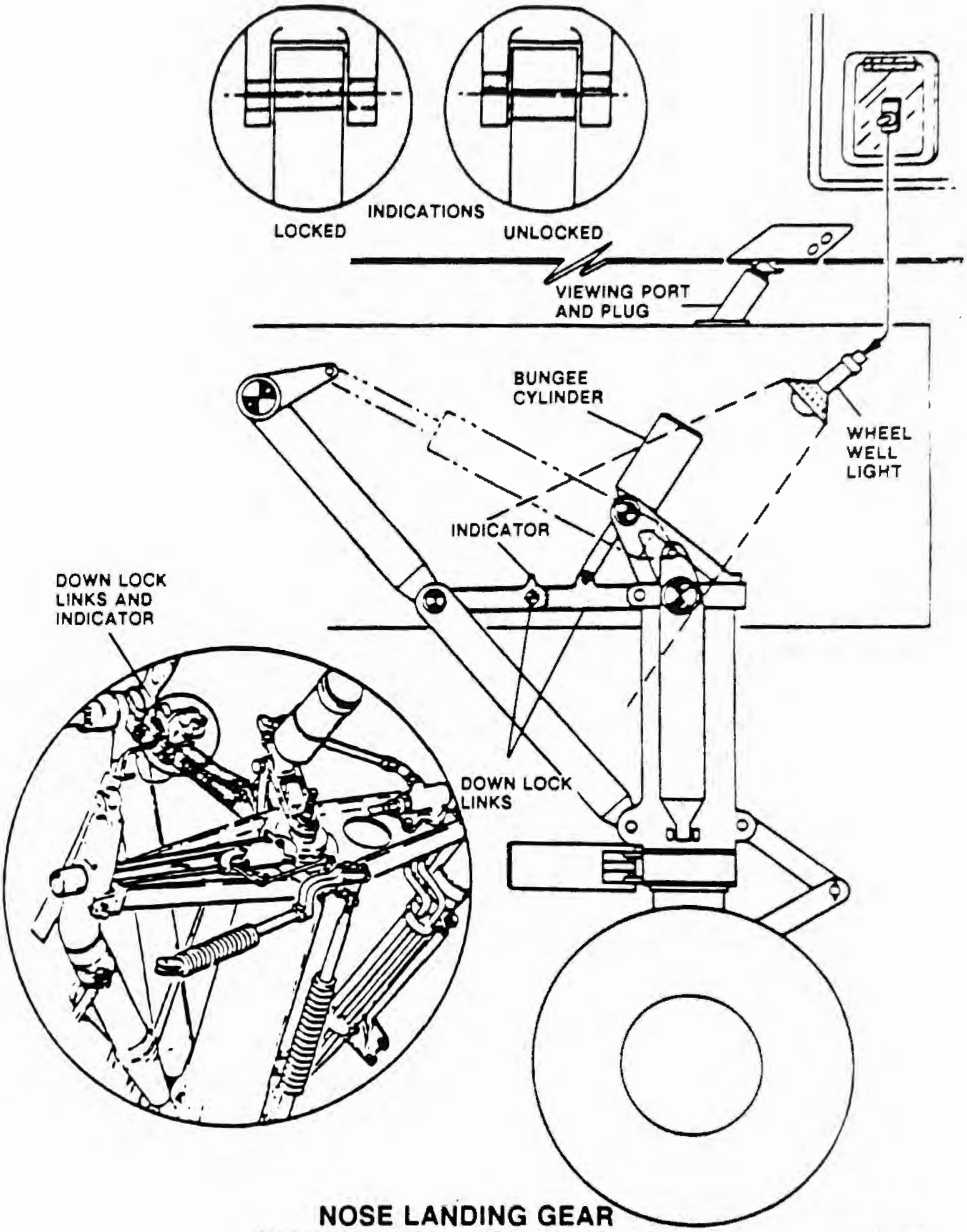
(1) A main gear downlock limit switch is mounted on the upper overcenter link on each main gear. The switch is attached with three bolts and is jig located to preclude adjustment. Each switch has sufficient overtravel to assure actuation without bottoming.

E. Main Gear Uplimit Switch

(1) A main gear uplatch switch is mounted on the uplatch bracket in each main gear wheel well. The switch is attached with three bolts, is jig located to preclude adjustment, and has sufficient overtravel to assure actuation without bottoming. These switches function only to indicate an unsafe gear up condition.

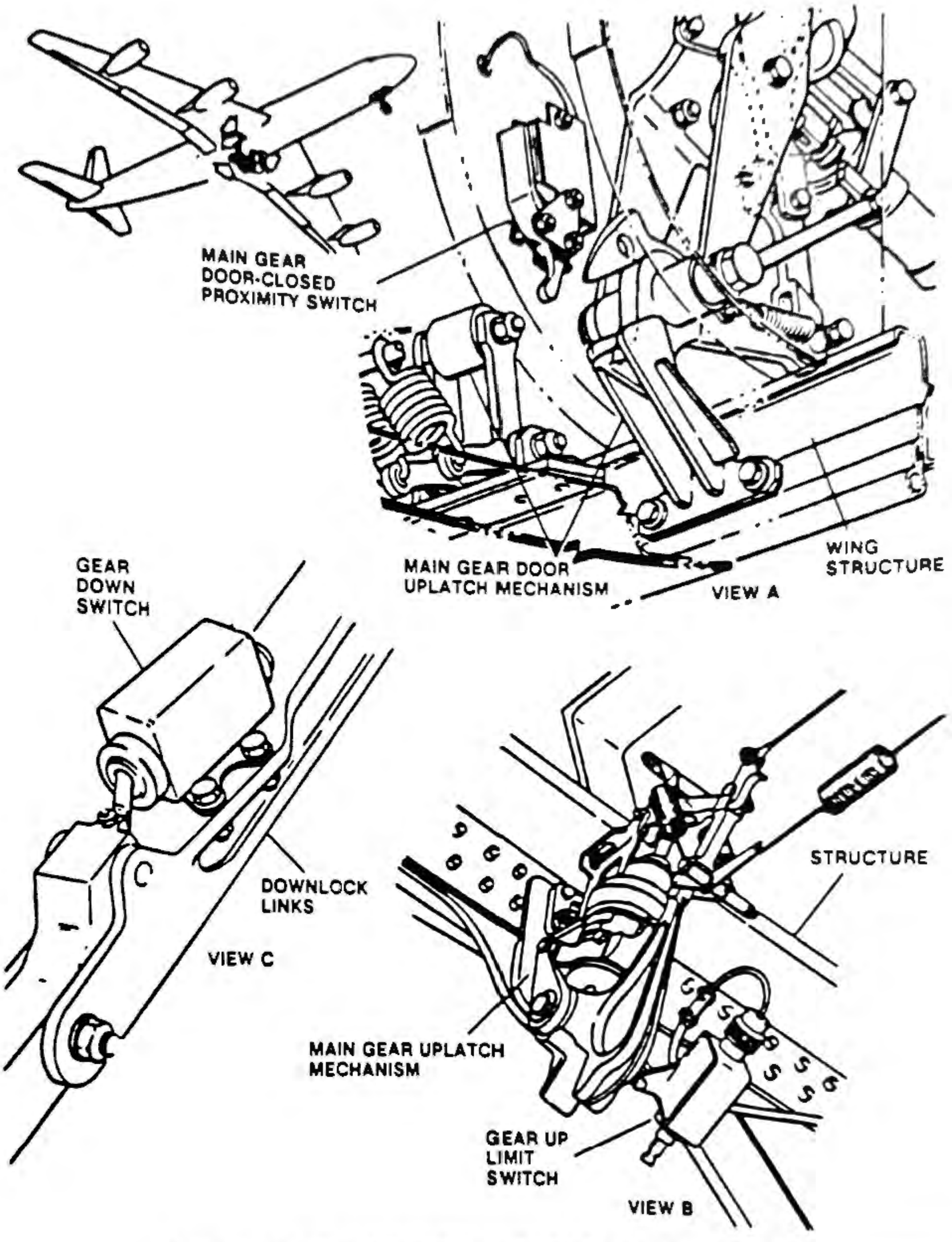
F. Main Gear Door-Closed Proximity Switch

(1) A main gear-door closed proximity switch is mounted on the fuselage main gear slide rail, adjacent to the door latch mechanism in each wheel well. Each switch, basically a stationary sensor and a movable target, is jig located to preclude adjustment. A target striker is located on each inboard door latch roller arm. When the doors are latched, the striker moves the target and deenergizes the circuit to the warning light.



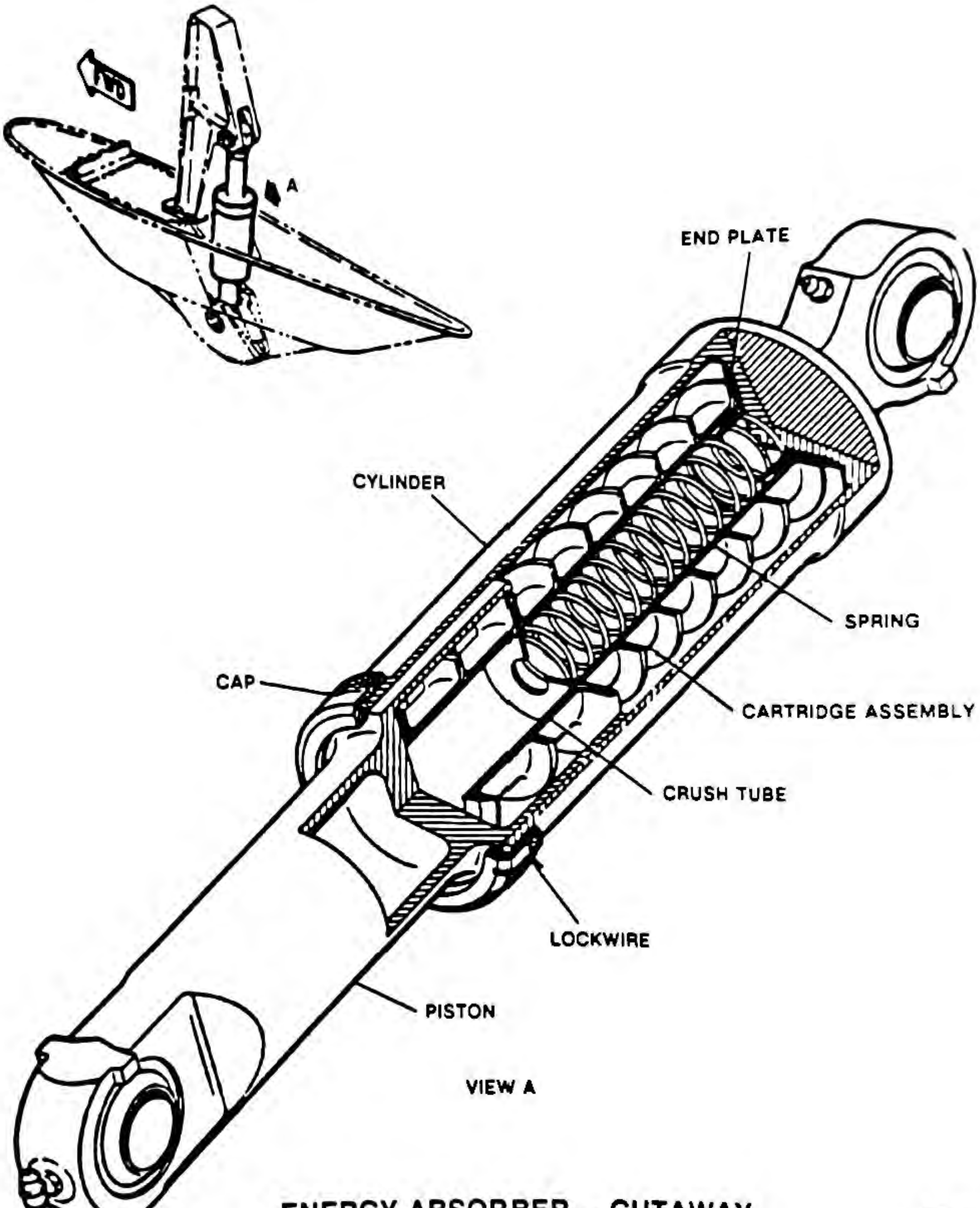
NOSE LANDING GEAR
VISUAL DOWNLOCK INDICATOR
Figure 32-84

FTX80184


MAIN GEAR DOOR-CLOSED PROXIMITY SWITCH
MAIN GEAR DOOR UPLATCH MECHANISM
WING STRUCTURE
VIEW A
GEAR DOWN SWITCH
DOWNLOCK LINKS
VIEW C
STRUCTURE
MAIN GEAR UPLATCH MECHANISM
GEAR UP LIMIT SWITCH
VIEW B

MAIN GEAR POSITION INDICATING SWITCHES FTX80185

Figure 32-85



ENERGY ABSORBER -- CUTAWAY

FTX80187

Figure 32-87

G. Proximity Switch Control Box

(1) A control box for the proximity switches is mounted on the generator control rack in the electrical power center. The control box relays signals from the proximity switch sensors to the main gear door not-latched-light. When the main gear doors are not latched, the light comes on. Conversely, when the main gear doors are latched, the light goes off. The control box is also provided with a self-test feature that is used to check the sensor circuitry for each of the proximity switches.

H. Nose Gear Downlock Limit Switch (See Figure 32-86)

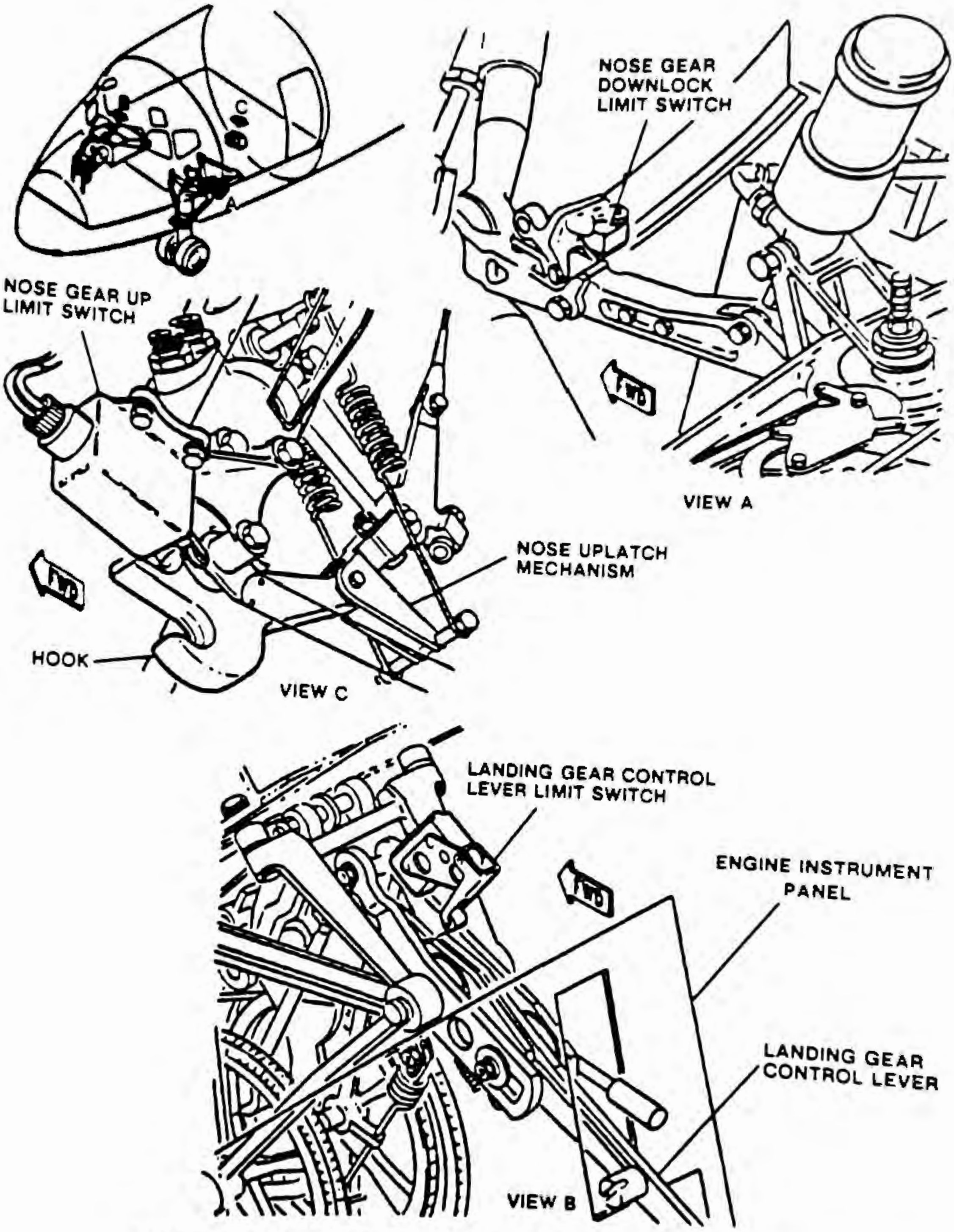
(1) A nose gear downlock limit switch is mounted on the aft overcenter link and is secured by three bolts. The switch striker is mounted on the forward overcenter link and actuates the switch when the links lock in the overcenter position. The switch is jig located to preclude adjustment and has enough overtravel to assure actuation without bottoming.

I. Nose Gear Uplimit Switch

(1) The nose gear uplimit switch is mounted in the uplatch bracket on the centerline in the nosewheel well. The switch is attached with three bolts and is jig located to preclude adjustment. The switch functions only to indicate an unsafe gear up condition.

J. Landing Gear Control Lever Limit Switch

(1) The landing gear control lever limit switch is mounted in the landing gear control lever bracket and is actuated by the long control lever. The switch is attached to the bracket by two bolts and is jig located to preclude adjustment. The switch is accessible through the landing gear control lever panel. It switches the gear indicating and warning systems from gear up position to gear down position and completes the circuit for the antiskid arming.


C
A
NOSE GEAR DOWNLOCK LIMIT SWITCH
FWD
VIEW A
NOSE GEAR UP LIMIT SWITCH
FWD
NOSE UPLATCH MECHANISM
HOOK
VIEW C
LANDING GEAR CONTROL LEVER LIMIT SWITCH
FWD
ENGINE INSTRUMENT PANEL
LANDING GEAR CONTROL LEVER
VIEW B

NOSE GEAR POSITION INDICATING SWITCHES

FTX80186

Figure 32-86

K. Landing Gear Not Latched Selector Switch

(1) A six position selector switch located on the system engineer's panel, used to select each uplock limit switch, to monitor its position. The switch is labeled, doors left, right and landing gear left, nose, right. The switch also has an off position. The function of this switch is if the red gear unsafe light stayed illuminated after gear retraction, the system engineer could locate which uplock that was not engaged by selecting each position of the selector switch and monitoring the amber not latch light.

L. Throttle Limit Switches

(1) Four throttle limit switches are included in the landing gear position and warning system circuitry, one for each throttle, and are located in the center control pedestal. Each switch is actuated by a cam operated by the corresponding throttle. Each switch can complete the circuit for the warning horn and red warning lights provided other conditions are met; if any throttle is in a position from idle to approximately 7 degrees from idle stop position. The throttle limit switches are accessible by removing the side panels on the center control pedestal.

M. Wing Flap Handle Landing Gear Warning Switch

(1) The wing flap handle landing gear warning switch is mounted in the right wheel well above the wind flap control sector. The switch is actuated by a cam which is mounted on the flap control aft sector. The switch completes a circuit to the warning horn when the landing gear is in an unsafe condition for landing, provided other conditions are met.

N. Landing Gear Warning Horn

(1) The landing gear warning horn is located in the captain's console and provides the flight crew with an audible warning if an unsafe condition for landing exists. The horn is accessible through the side panel on the captain's console. The landing gear warning horn produces a steady, continuous sound. The takeoff warning horn produces an intermittent sound.

(3) If the wing flap handle is out of the up positon when the gear is not down and locked, the horn sounds when one or more engine throttle is moved back to a position approximately 7 degrees from idle stop. The horn also sounds any time that the landing gear control lever is out of the down detent with the flap and engine throttle limit switches actuated. The horn may be silenced by depressing the horn cutoff switch, providing the flaps are not extended 35 degrees or more.

19. 63 Differences

The following differences are associated with the 63 series aircraft:

The main landing gear tires
The main landing gear brakes
The nose wheel steering angle
Supplementary gear

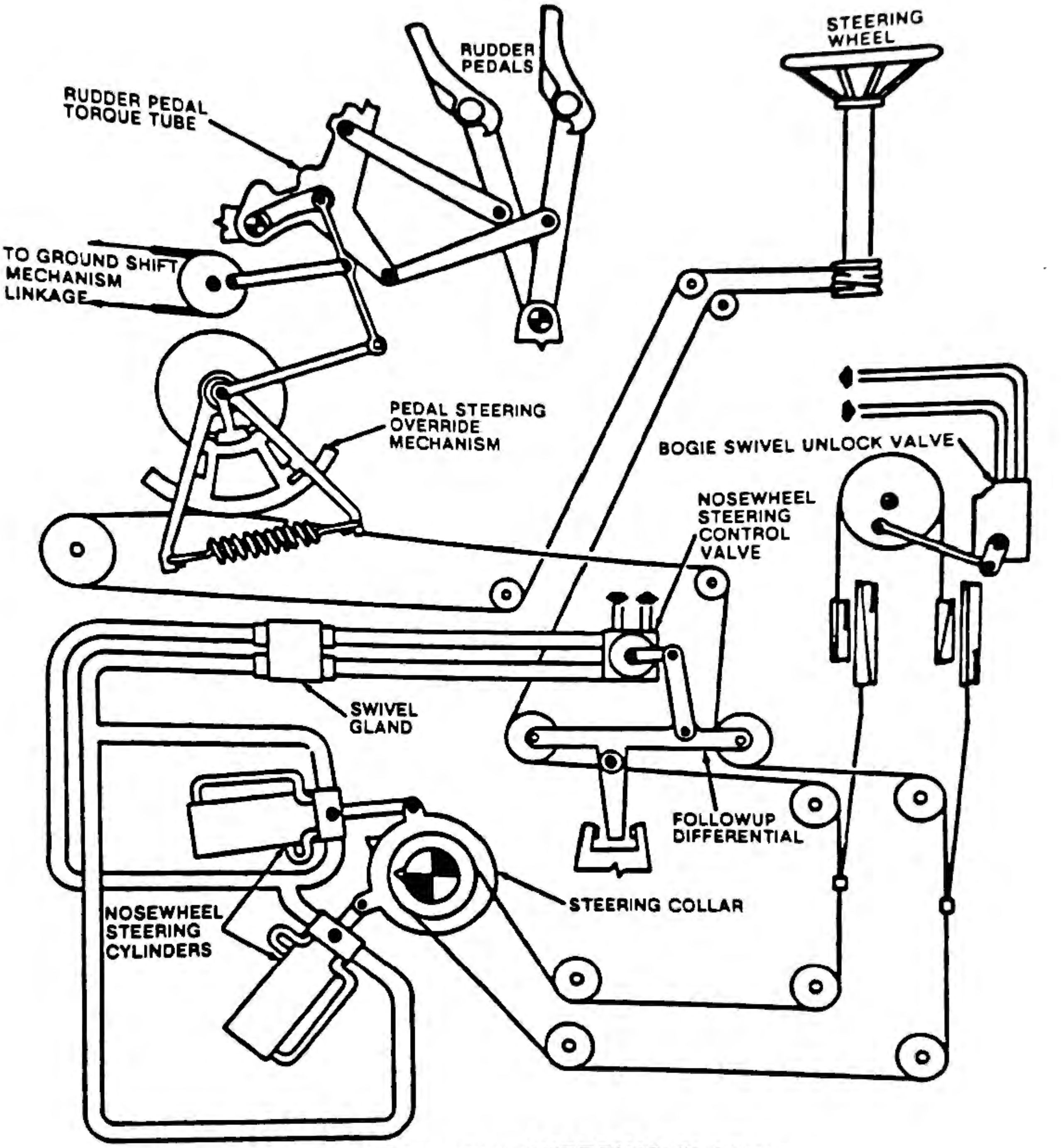
A. Main Gear Wheel and Tire Assemblies

(1) The main gear wheels are Bendix 44X16, type VII. The wheels are split to facilitate tire removal and mounting. Both wheel halves are machined from forged aluminum. The split between the wheel halves is sealed by an O-ring to make the wheels airtight for use with tubeless tires. The tires are 44.5X16.5-18, nylon fabric tubeless tires.

(2) A standard tapered wheel bearing is installed in each wheel half. Adjustment of the bearings is controlled by the axle nut. The inner bearings are protected against loss of lubricant and the entrance of dirt by moisture-resistant, silicone-impregnated felt seals which wipe on aluminum wipers. The seal is mounted on the axle between the bearing spacer and the bearing cone.

B. Main Gear Wheel Brakes

(1) The main gear wheel brakes are multi-disc, hydraulic power brakes consisting of seven rotating and eight stationary elements. The rotating elements (rotors) are keyed into the wheel and are segmented to reduce warpage. The stationary elements are integral with the brake assembly and are fitted with replaceable linings.


RUDDER PEDALS
STEERING WHEEL
RUDDER PEDAL TORQUE TUBE
TO GROUND SHIFT MECHANISM LINKAGE
PEDAL STEERING OVERRIDE MECHANISM
BOGIE SWIVEL UNLOCK VALVE
NOSEWHEEL STEERING CONTROL VALVE
SWIVEL GLAND
FOLLOWUP DIFFERENTIAL
STEERING COLLAR
NOSEWHEEL STEERING CYLINDERS

NOSEWHEEL STEERING SYSTEM

FTX80190

Figure 32-88

(2) The brake carrier assembly consists of a carrier and a backing plate. The carrier houses seven retract spring assemblies, seven hydraulic piston assemblies, two bleed ports, a fluid inlet port, and interconnecting fluid passageways. The backing plate is attached to the carrier, and the shaft of the backing plate is splined and serves as the index and support for the stators and the pressure plate. There are seven brake linings riveted to the inner face of the backing plate. The backing plate absorbs and transfers the brake torque to the carrier. The area between the inner face of the backing plate and the carrier houses the stators, rotors, and the pressure plate.

(3) The scalloped, disc-shaped, pressure plate has seven brake linings riveted to the inner face. The pressure plate applies pressure from the pistons to the rotors and stators. The pressure plate is retained by the seven return spring assemblies. The inner circumference of the pressure plate is slotted to index with the splines on the backing plate shaft.

(4) The seven retract springs are installed in equally spaced housing which are integral with the carrier. The retract spring assemblies act as automatic adjustors for each brake.

(5) The hydraulic piston assemblies are contained in seven equally spaced housings around the carrier, and consist of a cylinder, piston, seals, and a pad. The head of the cylinders are open to internal fluid passageways in the carrier. When hydraulic pressure is applied to the head of the pistons, the seven pads apply a uniform force against the pressure plate.

(6) Eight stator plates serve as the intermediate lining-carrying members. Seven linings are mounted back-to-back on each plate by two rivets. The stator is scalloped between the lining locations on each plate to provide warpage control, reduce weight, and increase air circulation. Brake torque is transmitted from the stator plates to the backing plate by several slots at the inside circumference of the plate. The slots are indexed to mate with backing plate splines.

(7) Each of the seven rotors consists of eight segments mounted on a steel spider. The outward radial movement of the segments, induced by high-rotational speed, is restricted by steel straps riveted to the ends

of the spider arms. Eight keyways are located around the circumference of each rotor and engage eight keys installed around the inner rim of the wheel.

C. Nose Wheel Steering

(1) The nosewheel steering system is a hydraulically actuated system which is mechanically controlled by a steering wheel, located on the left side of the flight compartment, and by the rudder pedals. The steering wheel controls 67 degrees of turning angle in either direction, and the rudder pedals control 15 degrees in either direction.

D. Supplementary Gear (See Figure 32-87)

(1) The supplementary gear consists of a tail skid and energy absorber assembly. The tail skid consists of a forged aluminum strut hinged on a structural fitting, supported by the energy absorber, and enclosed in an aluminum fairing on the lower surface of the aft section of the fuselage on the airplane centerline.

(2) The tail skid energy absorber consists of a cylinder, piston, and a compression cartridge. The energy absorber is attached to the structural fitting and the skid, and is mounted with the piston end connected to the structural fitting.

(3) The energy absorber cartridge consists of three parts: a crush tube, return spring, and an end plate. The crush tube, when driven by the piston and the end plate, is designed to compress under heavy loading and to absorb the load imposed by the tail skid. A return spring is installed inside of the crush tube and is used to return the piston to the extended position after any degree of crush tube compression.

(4) The purpose of the tail skid and energy absorber is to provide a contact point for the fuselage to touch the ground and to absorb the shock of that contact, if the airplane should assume such an attitude that would lower the aft section of the fuselage to ground level.

20. 61 Differences

The following differences are associated with the 61 series aircraft:

Main landing gear bogie beam assembly
Emergency air brake system
Nose wheel steering
Bogie swivel unlock system
Supplementary gear (same as 63 series)

21. Emergency Airbrake Pressure Bottle

The emergency airbrake pressure bottle is a spherical, steel container used for storing dry nitrogen under pressure at 3000 psi for use in the emergency airbrake system. The pressure bottle is located approximately 18 inches aft of the wing rear spar on the wing shear web in the left wing root area and is bolted to the web structure forward and above the auxiliary hydraulic pump.

22. Nose Wheel Steering

A. General

(1) The nosewheel steering system is a hydraulically actuated system which is mechanically controlled by a steering wheel, located on the left side of the flight compartment, and by the rudder pedals. The steering wheel controls 74 1/2 degrees of turning angle in either direction, and the rudder pedals control 15 degrees in either direction.

(2) The nosewheel steering mechanical control system consists of a steering wheel and cable drum assembly, a 2-way cable system, a pedal steering override mechanism, a followup differential, a ground shift mechanism, and a main gear bogie swivel unlock cable system.

(3) The steering wheel cable drum is the terminus of the nosewheel steering cable system. One cable connects the steering wheel cable drum to the pedal steering override mechanism, and the other cable beginning at the pedal steering override mechanism, passes through the followup differential, around the nosewheel steering collar, back through the followup differential, and terminates at the steering wheel cable drum.

(4) The pedal steering override mechanism permits 15 degrees of steering control in either direction through use of the rudder pedals. This mechanism contains a locking cam and pushrod that locks out pedal steering during gear retraction. The followup differential mechanism transfers cable motion to the hydraulic control valves to steer the nosewheels.

(5) The ground shift mechanism positions the pedal steering override mechanism to permit use of the rudder pedals for limited nosewheel steering while the nose gear strut is compressed and to disengage or lockout rudder pedal steering when the nose gear strut is extended.

(6) The main gear bogie swivel unlock cable system, which is bridled to the nosewheel steering system, actuates the bogie swivel unlock control valve during ground maneuvers.

(7) The nosewheel steering hydraulic control system consists of a steering control valve, two steering cylinders, a relief valve, pressure accumulator, and two reserve pressure accumulators and associated smaller items. The steering control valve is mechanically connected to the nosewheel steering cable system through linkage with the followup differential mechanism.

(8) The nosewheel steering hydraulic control valve receives hydraulic pressure from the landing gear control system down-pressure line, thereby permitting the system to be actuated only when the gear is extended. The pressure accumulator assists in preventing any tendency of the nosewheels to shimmy by supplying 150 psi hydraulic pressure to both steering cylinders when the steering control valve is in the neutral position.

(9) Two reserve pressure accumulators in the nosewheel steering system assure a supply of pressure, after the gear is extended and the strut is compressed, for steering if main hydraulic system pressure is lost.

23. Nosewheel Steering Mechanical Control System - Description and Operation

A. General (See Figures 32-88 & 32-89)

(1) The nosewheel steering mechanical control system consists of a 2-way, closed circuit cable system, a rudder pedal steering override mechanism, a nosewheel steering followup differential mechanism, and a steering wheel assembly. The system is manually operated by the steering wheel and/or the rudder pedals.

(2) The nosewheel steering system cables extend from the cable drum on the steering wheel shaft to the pedal steering override assembly, to the steering control valve followup differential assembly, and to the steering collar on the nose gear strut.

B. Steering Wheel and Drum (See Figure 32-90)

(1) The steering wheel is the primary control used to steer the airplane during ground maneuvers. The steering wheel is located on the forward end of the captain's console. When the indicator on the rim of the steering wheel is at the 12 o'clock position, the steering wheel is in the neutral position and the nosewheels are in the straight forward position.

(2) The wheel and drum assembly consists of a control wheel, wheel support assembly, bushing, tube, parking brake knob, spring and cable, retainer, and a cable drum assembly. The wheel is bolted to the support assembly by four bolts. The support assembly is riveted to the tube assembly. The tube assembly retains the spring, seat, and spring retainer ring for the parking brake knob, located in the center of the steering wheel. The cable drum is attached to the lower end of the steering wheel shaft.

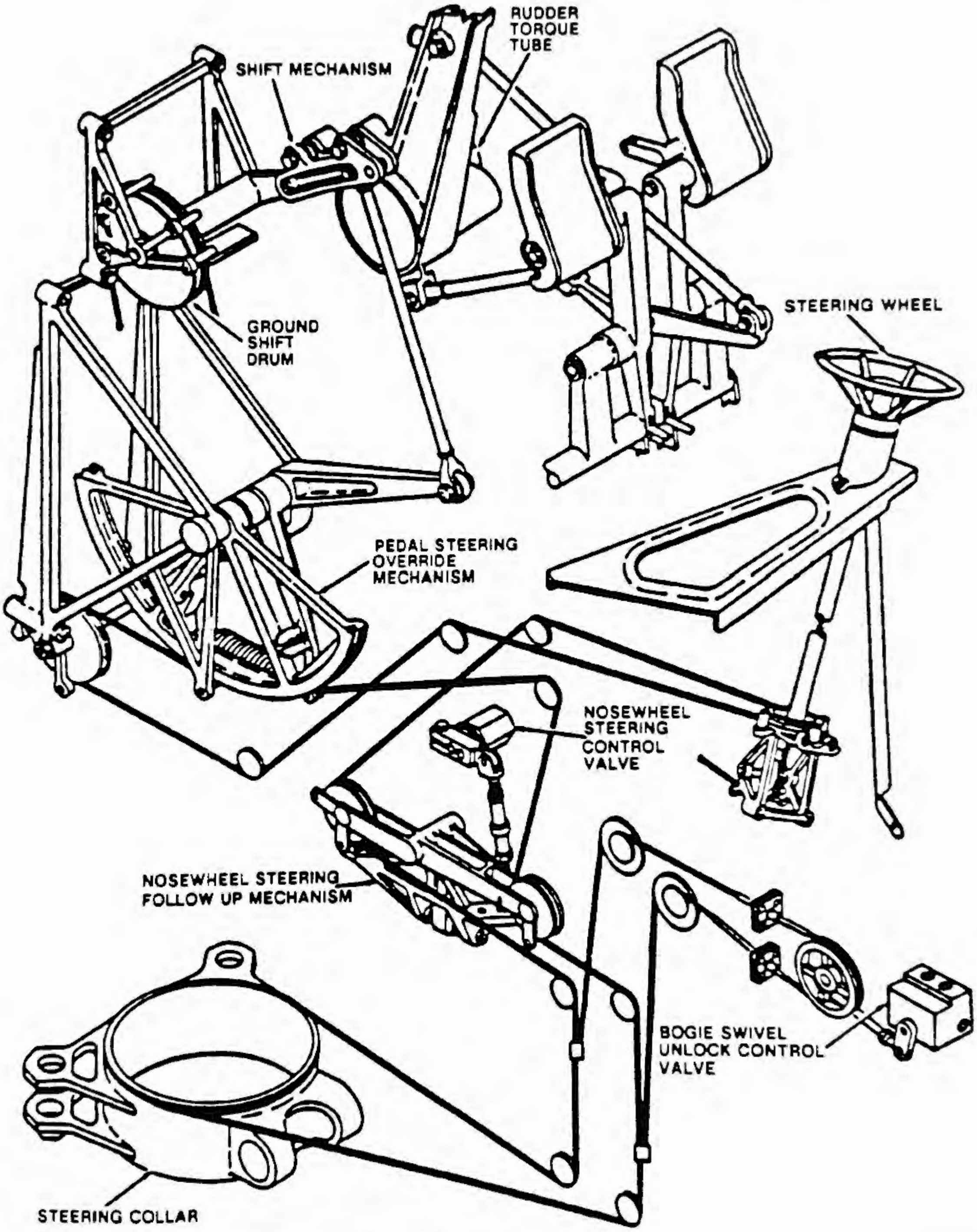
(3) The steering wheel assembly is attached to the console by a support bracket. The shaft rides in a bearing at the upper support bracket and a bearing in the lower bracket. The lower bracket incorporates the support for the parking brake guide cable pulley and guard pins for the steering drum cables.

(3) A manual control arm is installed on the aft pulley of the followup differential and protrudes through a slot in the left bulkhead of the nosewheel well. The control arm is used to facilitate alignment of the nose gear torque links during reengagement of the nose gear torque link lockpin. A placard is mounted adjacent to the control arm and indicates the direction to move the arm for right or left steering.

24. Bogie Beams (See Figure 32-93)

A. The bogie beam assembly consists of a forward stationary beam and an aft swivel beam. The forward end of the beam has a dual-wheel axle, a clevis fitting for mounting the bogie trim cylinder, and a mounting stud for the bogie swivel unlock cylinder. A boss for the overcenter spring is located below the forward inboard axle. The bogie pivot arm is fitted into lugs that attach to the forward inboard side of the beam, and the pivot arm actuator is attached to the top of the pivot arm. The lower end of the pivot arm is connected to the overcenter linkage and return spring. The aft swivel beam has an unlock arm that extends forward to join with the unlock mechanism and supports the aft dual-wheel axle.

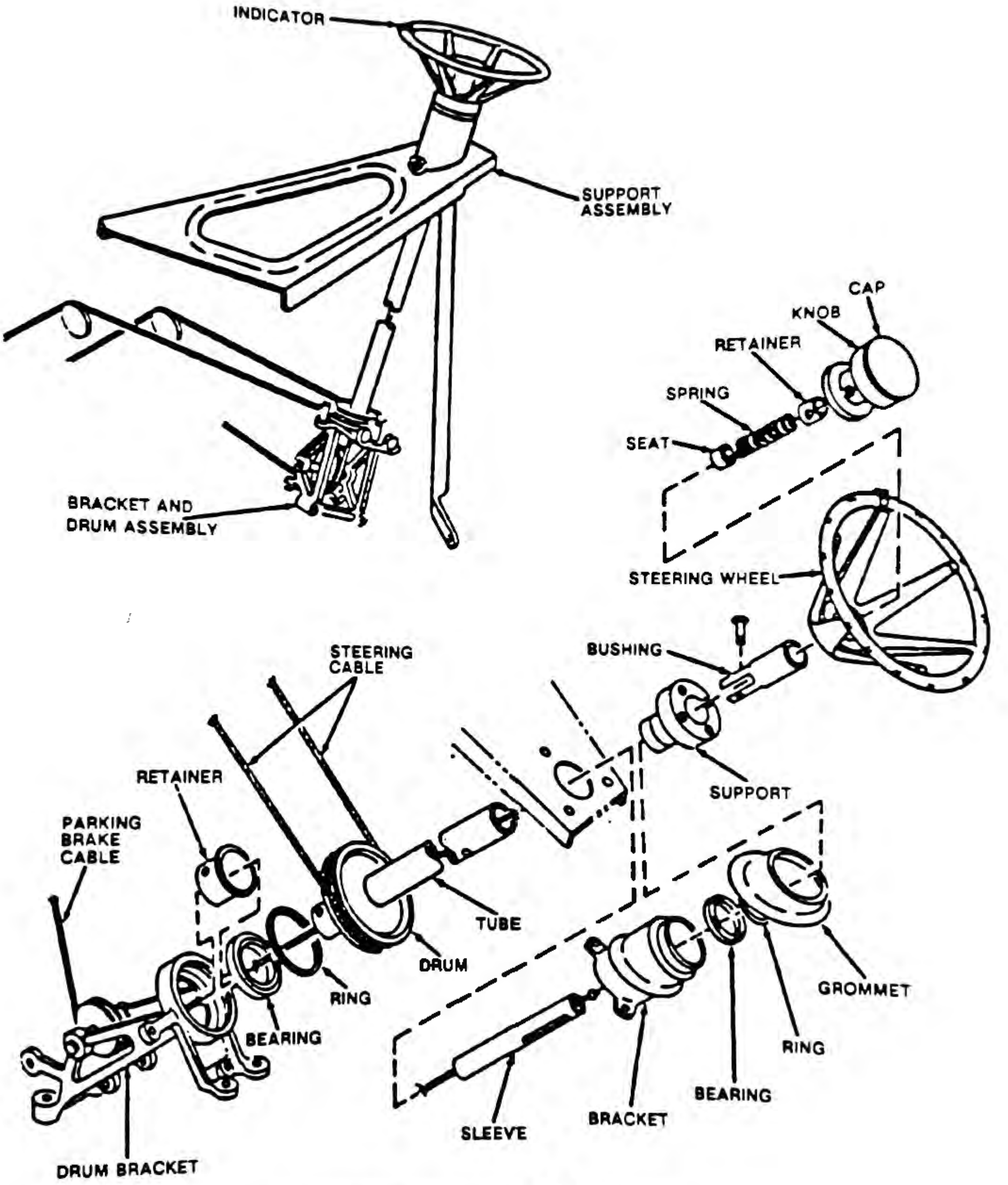
B. The bogie beam has two functions. First, to pivot on the end of the main gear strut piston to provide even distribution of airplane weight to all main gear wheels, and to allow the wheels to follow the contour of the terrain over which the airplane is taxied or towed. Second, the aft portion of the beam swivels to facilitate turning the airplane without scrubbing the rear tires of the gear on the inside of the turn.


RUDDER TORQUE TUBE
SHIFT MECHANISM
GROUND SHIFT DRUM
STEERING WHEEL
PEDAL STEERING OVERRIDE MECHANISM
NOSEWHEEL STEERING CONTROL VALVE
NOSEWHEEL STEERING FOLLOW UP MECHANISM
BOGIE SWIVEL UNLOCK CONTROL VALVE
STEERING COLLAR

NOSEWHEEL STEERING SYSTEM

FTX80191

Figure 32-89



STEERING WHEEL AND DRUM

FTX80192

Figure 32-90

C. Pedal Steering Override Mechanism (See Figure 32-91)

(1) The pedal steering override mechanism is the connecting assembly that links the rudder pedal steering to the normal (steering wheel) mechanical control system. The rudder pedal linkage provides a maximum of 15 degrees steering control to either side of neutral. The mechanism is spring loaded to the neutral position and returns the steering wheel to neutral from any degree of rotation.

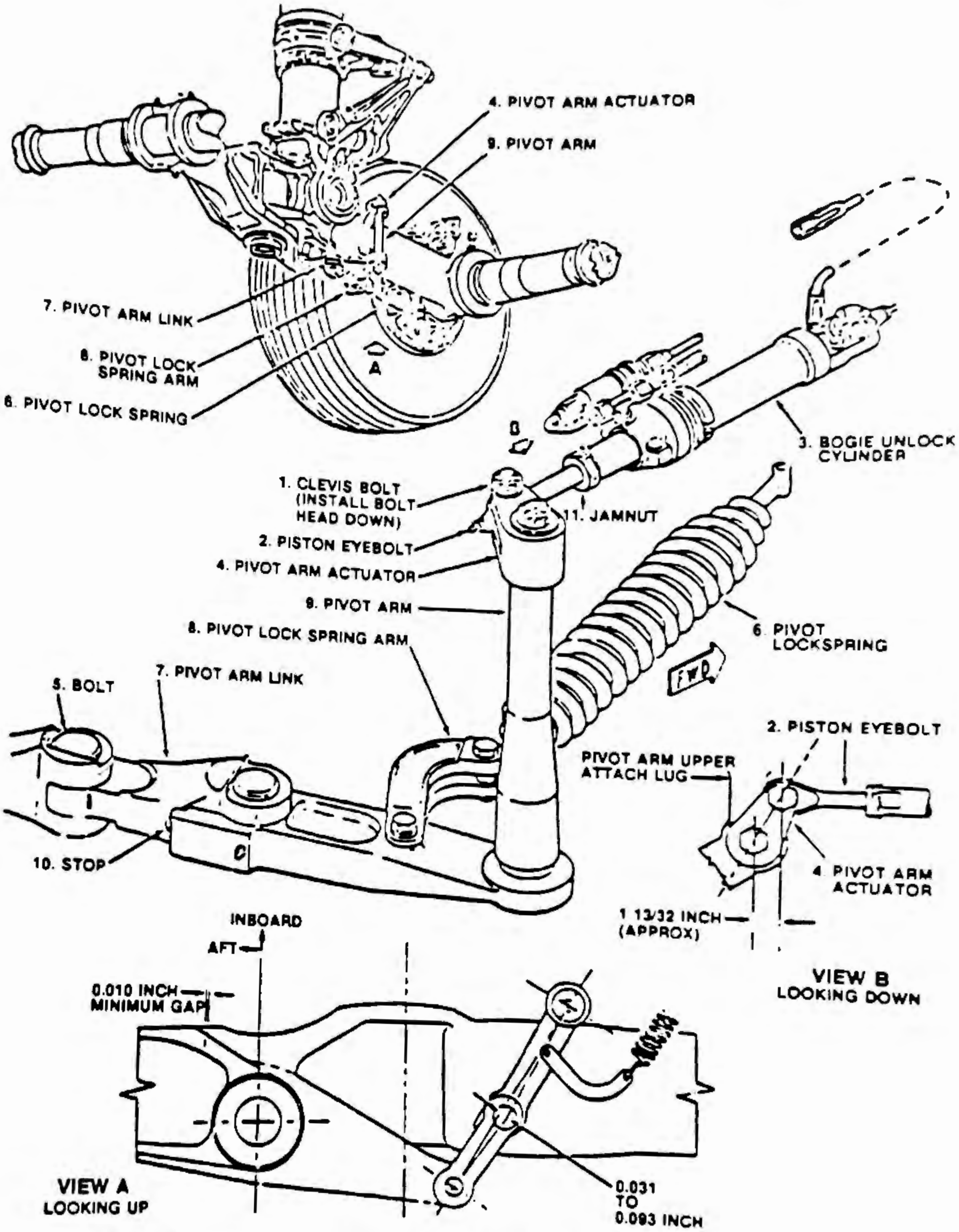
(2) The override mechanism consists of a bracket in which the following assemblies are mounted: a sector, drive arm, two spring-loaded actuator arms with a spring between them, a phenolic rub strip to protect the ground shift cable, and a common support axle.

(3) The sector and two spring-loaded arms have adjustable stops to adjust the mechanism to zero lash. The drive arm is attached to the pushrod which is attached to the shift drum and cam follower.

D. Nosewheel Steering Followup Differential Mechanism (See Figure 32-92)

(1) The nosewheel steering followup differential mechanism transmits cable motion through linkage to actuate the steering control valve. The assembly also serves as a followup to return the control valve to the neutral position when the desired angle of nosewheel turn has been reached. The differential assembly is bearing mounted to the support bracket, off center to the beam centerline, and is free to rotate in two directions. The control valve linkage is attached to the link attach arm near the aft end fitting of the differential beam. A pulley is mounted on each end of the beam, and the steering cables are routed through the pulleys.

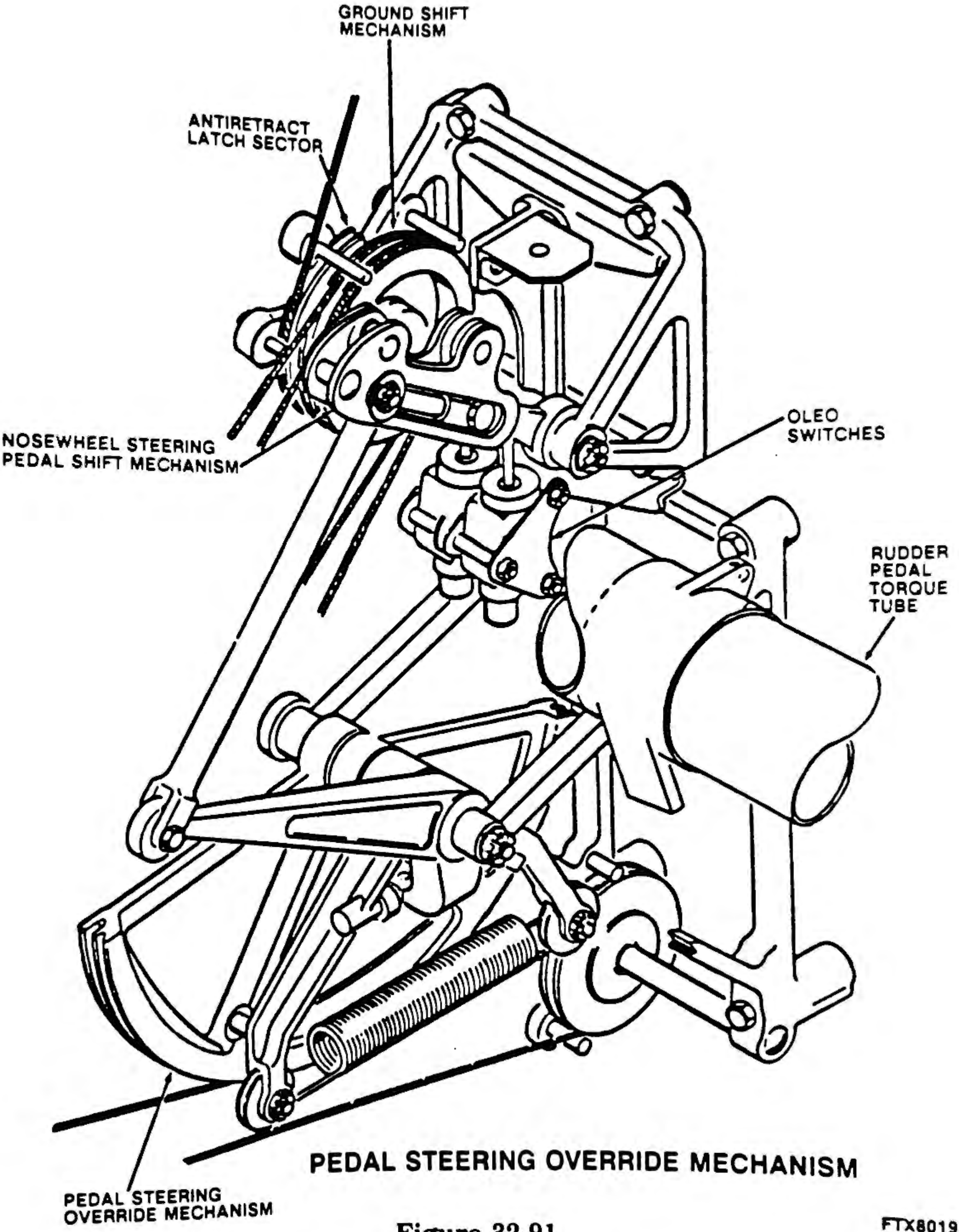
(2) As the steering wheel is displaced, tension is increased on the turn cable. This tension unbalances the differential followup on its pivot axis and, through linkage, opens the steering control valve. As the nosewheels turn, tension on the turning cable is relieved, allowing the differential to return the control valve to neutral position.



BOGIE SWIVEL UNLOCK MECHANISM INSTALLATION

FTX80189

Figure 32-95



PEDAL STEERING OVERRIDE MECHANISM

Figure 32-91

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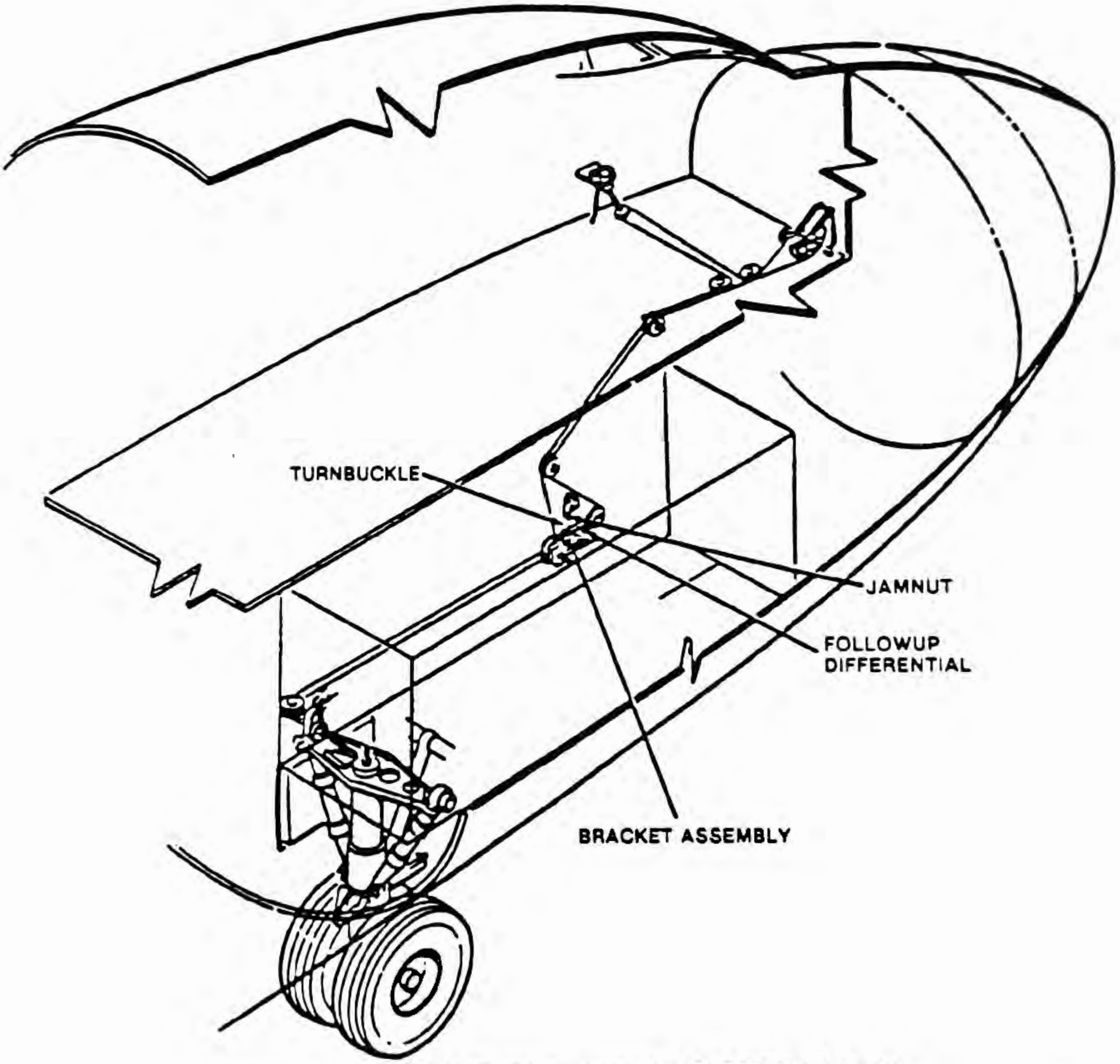

NOSEWHEEL STEERING FOLLOWUP DIFFERENTIAL

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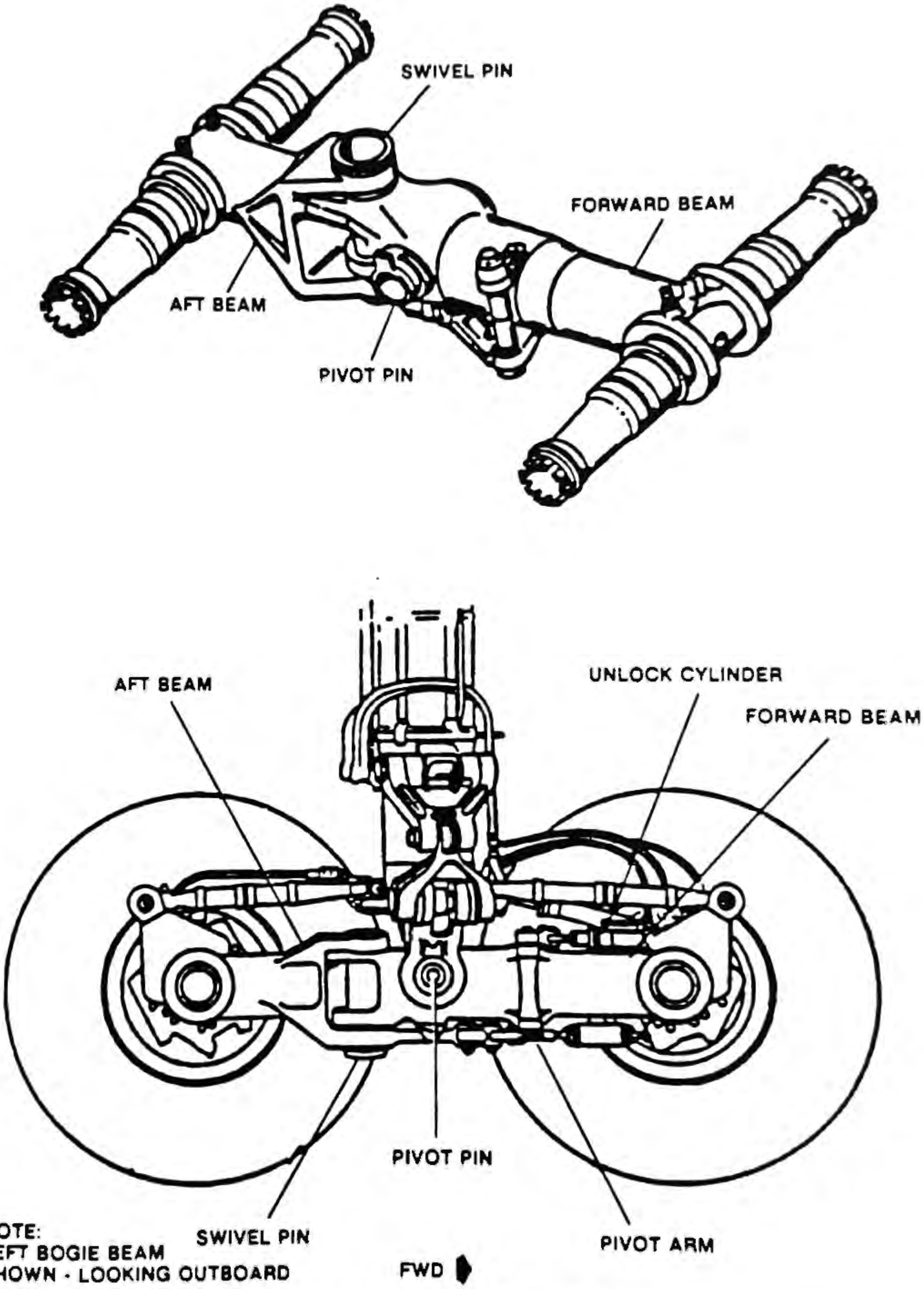
Figure 32-92



NOTE:
LEFT BOGIE BEAM
SHOWN - LOOKING OUTBOARD

MAIN GEAR BOGIE BEAM

FTX80188

Figure 32-93

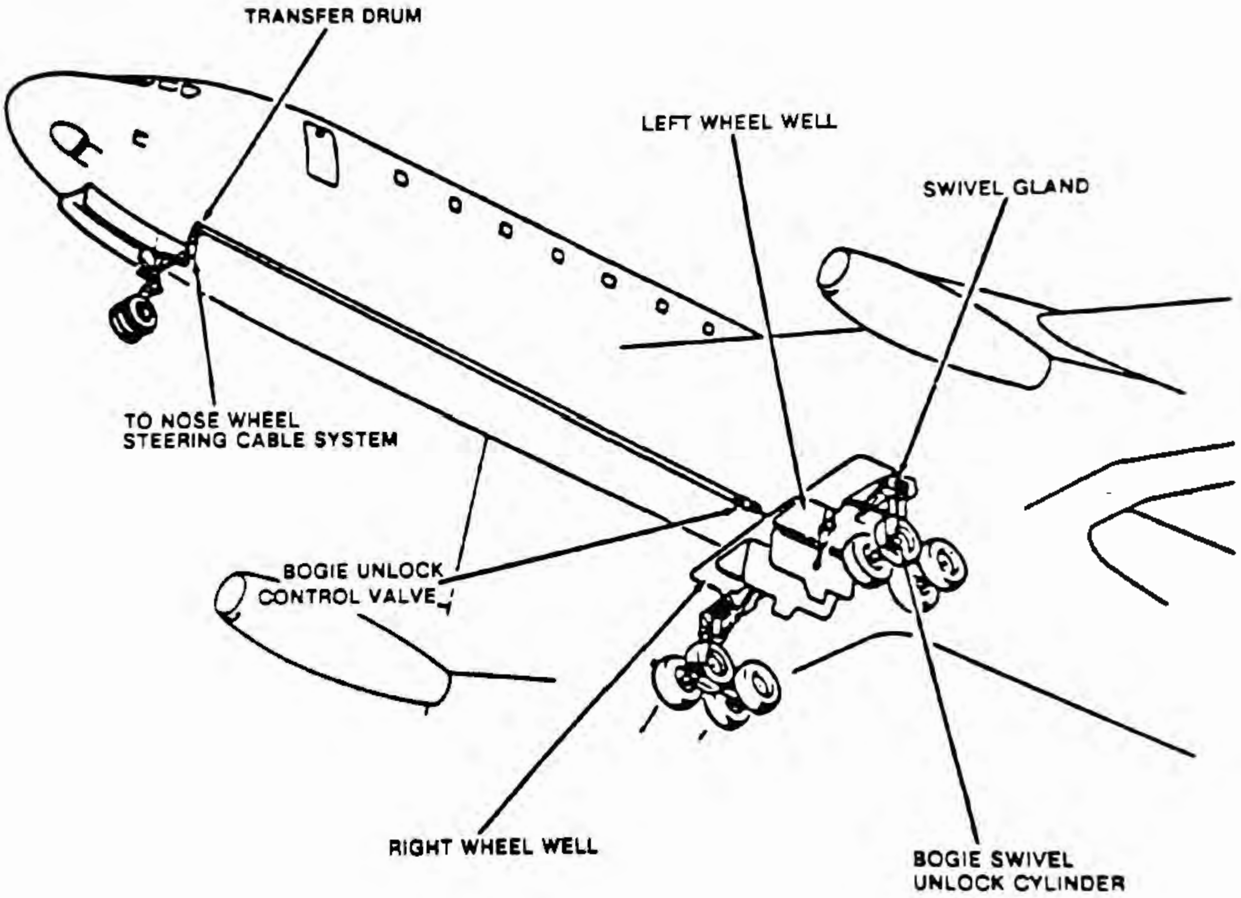
C. Operation

(1) When the ground shift mechanism has been shifted to the strut-compressed position, movement of the rudder pedals, either by depressing the pedals or by using the rudder trim system, moves the override mechanism and causes the nosewheel and the steering wheel to be displaced. Depressing either rudder pedal moves the pushrod connected to the ground shift mechanism. The pushrod, attached to the drive arm of the override mechanism, moves the override drive sector through the spring-loaded actuator arms. The sector moves, applying tension to the turning control cable and causing the followup differential to be moved. The followup differential opens the nosewheel steering control valve and directs pressure to the steering cylinders to produce up to 15 degrees of turning angle in the desired direction. The steering wheel in the flight compartment can be used to override the pedal steering at any time due to the spring-loaded connection in the override mechanism. When the steering wheel moves the cable to a position in excess of the maximum pedal steering movement, the override sector continues to move. This stretches the spring and permits the override sector to move the applicable spring-loaded actuator arm away from the drive arm.

25. Bogie Swivel Unlock Mechanism (See Figures 32-94 & 32-95)

A. The bogie swivel unlock mechanism is a hydraulically operated mechanical means of unlocking the aft section of the bogie beam. A spring-loaded overcenter linkage is attached to the swivel unlock cylinder piston, which is mounted on the forward end of the bogie beam. The unlock linkage consists of an actuator arm, which links the piston to the pivot arm, and a pivot lock spring arm, which secures the pivot lock spring to the actuator arm and spring loads the linkage overcenter.

B. When the nosewheels are turned 40 degrees or more in either direction, the nosewheel steering cable system actuates the bogie unlock system cables, which actuate the unlock control valve to port pressure to the unlock cylinder on the bogie beam that is on the inboard side of the turn. This unlocks the bogie and permits the aft section of the bogie to caster with the turn and prevent the tires from scrubbing. When the nosewheels pass the 18-degree position during return to the neutral position, the controls are positioned to lock the bogie. When the aft bogie is in trail position the overcenter linkage locks.



BOGIE SWIVEL UNLOCK MECHANISM

FTX80195

Figure 32-94

26. Bogie Swivel Unlock Hydraulic System - Description and Operation

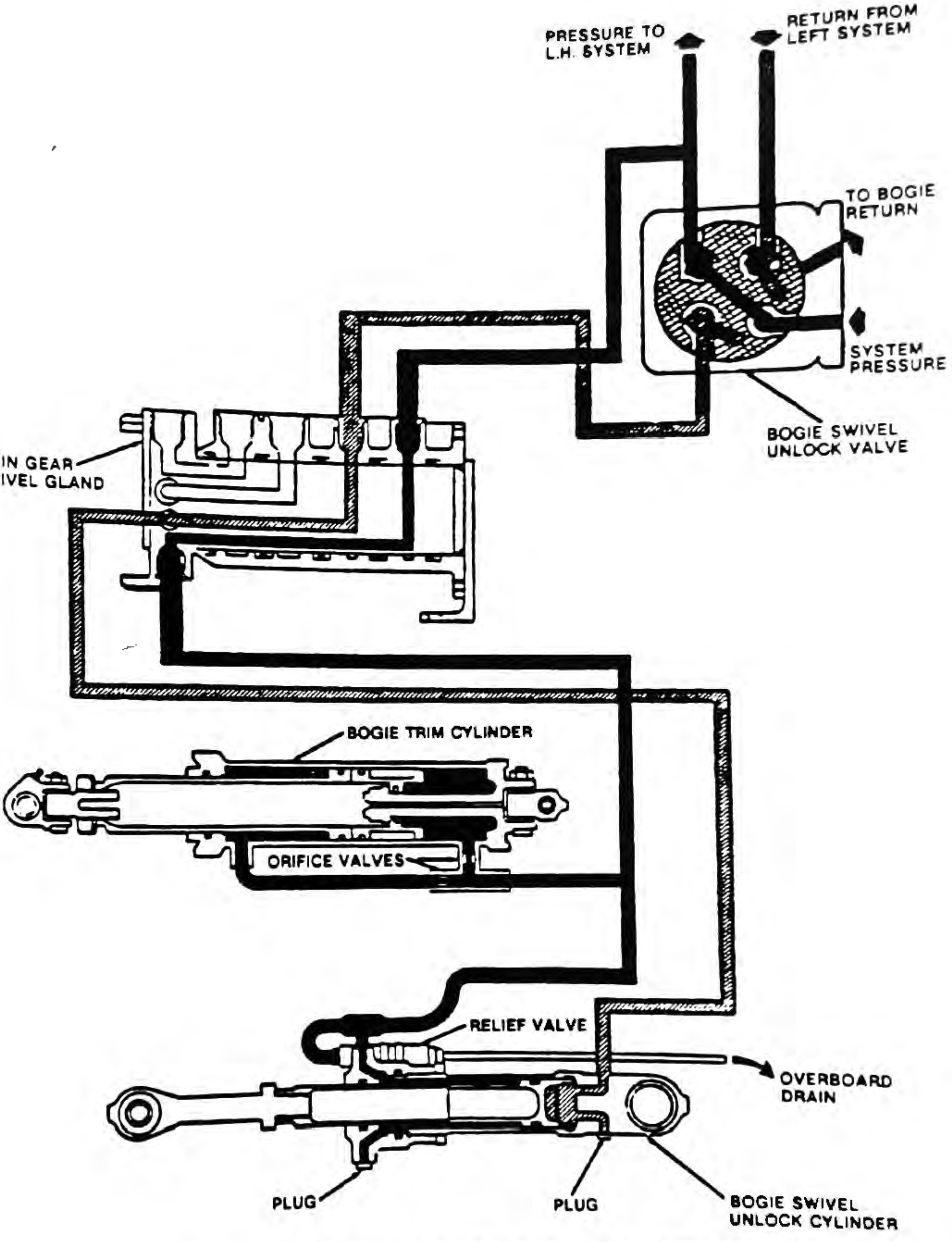
A. General (See Figure 32-96)

(1) The bogie swivel unlock hydraulic system is hydraulically actuated but mechanically operated by a cable system connected to the nosewheel steering cable system. When the nose gear wheels are turned 40 degrees from the straight forward position, the aft pair of main gear wheels on the inside of the turn are hydraulically unlocked and are allowed to swivel with the turn.

(2) The bogie swivel unlock hydraulic system consists of a bogie swivel unlock control valve, two bogie swivel unlock cylinders, and two cylinder relief valves. The bogie swivel unlock control valve, mounted on the left power manifold in the left main gear wheel well, receives hydraulic power through the manifold directly from the main hydraulic power system.

B. Bogie Swivel Unlock Control Valve

(1) The bogie swivel unlock control valve, located on the left power manifold, has three positions: neutral, left and right. The bogie trim cylinder and the locked side of the bogie swivel unlock cylinder are hydraulically connected in series. When the bogie swivel unlock control valve is in the neutral position, hydraulic system pressure is directed to the bogie trim cylinders and to the locked side of the bogie swivel unlock cylinders. At the same time the unlocked side of the bogie unlock cylinders is ported to hydraulic system return. When the bogie swivel unlock control valve is in the left position, hydraulic pressure is ported to the unlock side of the left bogie swivel unlock cylinder. At the same time, both bogie trim cylinders and the unlock and lock ports of the right bogie swivel unlock cylinder are ported to the hydraulic system return. During a right turn, the opposite porting applies.



BOGIE SWIVEL UNLOCK HYDRAULIC SYSTEM

FTX80196

Figure 32-96

C. Bogie Swivel Unlock Cylinders

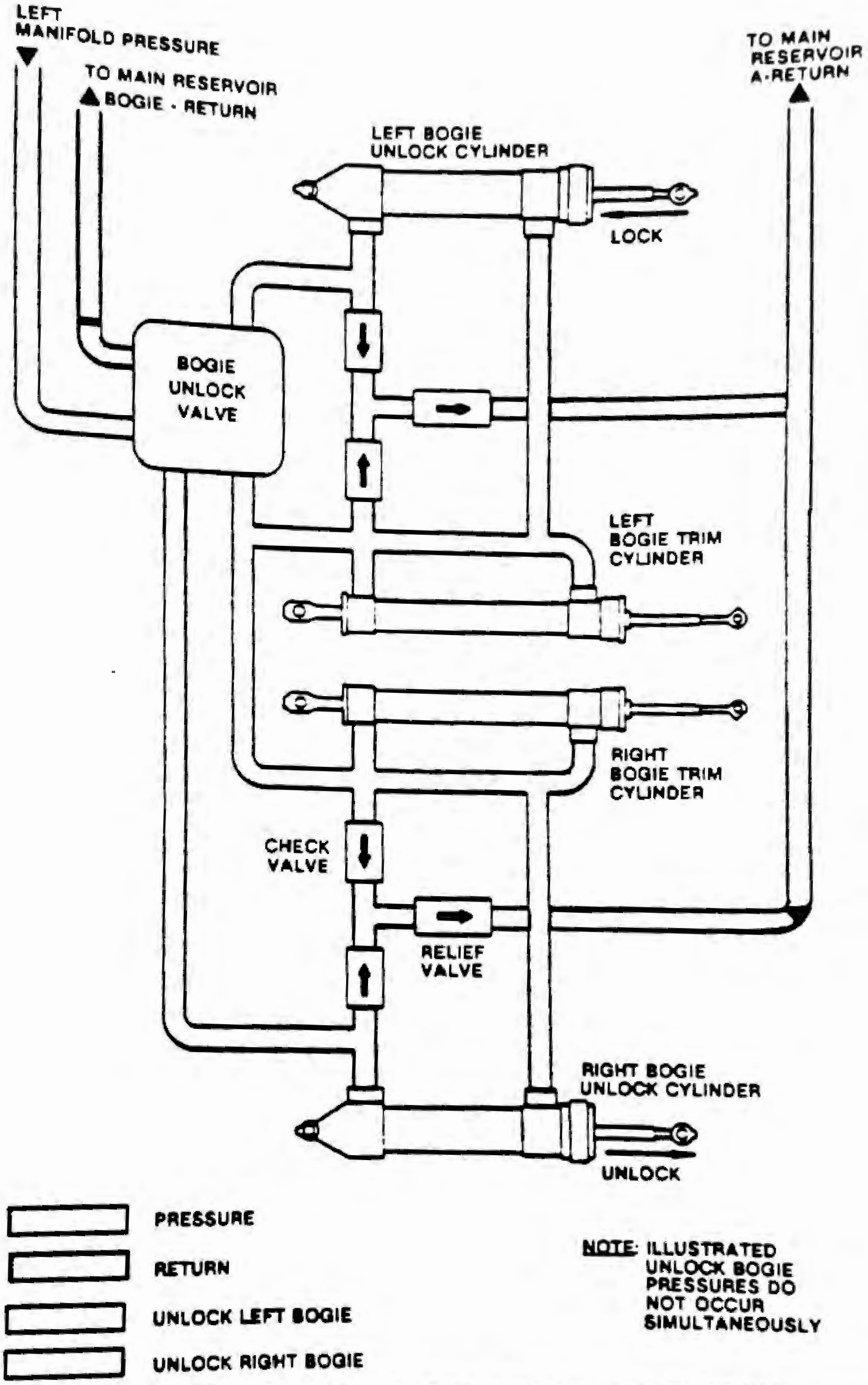
(1) The bogie swivel unlock cylinders are standard, 2-way actuating hydraulic cylinders used to lock or unlock the aft section of main gear bogie beams during ground maneuvers. The cylinders are mounted on the forward end of each bogie beam. The piston rod end is attached to the actuating linkage to unlock a spring-loaded overcenter locking linkage, and the body of the cylinder is attached to a boss on the bogie beam. An overboard relief valve is installed in each unlock cylinder pressure line adjacent to the cylinder. The relief valves open at 5650 (+75) psi and reseat at 5475 (minimum) psi. The relief valves protect the hydraulic lines and the unlock mechanisms in case of sudden pressure buildup.

D. Operation (See Figure 32-97)

(1) When the nosewheels are turned 40 degrees to the left, the nosewheel steering system cables actuate a cable system that controls the bogie swivel unlock control valve. The bogie swivel unlock control valve is rotated in a counterclockwise direction and ports hydraulic pressure to the left bogie swivel unlock cylinder. This unlocks the linkage and allows the left gear aft wheels to swivel with the turn. While hydraulic pressure is being directed to the left bogie swivel unlock cylinder, the right bogie swivel unlock cylinder and the two bogie trim cylinders have been opened to the hydraulic system return through the swivel unlock control valve.

(2) As the nosewheels are returned to 18 degrees, the swivel unlock control valve is returned to neutral position by the cable system. In this position, the swivel control valve ports pressure to both bogie trim cylinders and to the lock side of the unlock cylinders, arming the left unlock cylinder to lock the rear wheels of the left bogie when they return to the trial position.

(3) When the nosewheels are turned to the right 40 degrees, the same sequence of operation occurs for the right bogie aft wheels as that described for the left aft wheels.


LEFT MANIFOLD PRESSURE
TO MAIN RESERVOIR BOGIE - RETURN
TO MAIN RESERVOIR A-RETURN
LEFT BOGIE UNLOCK CYLINDER
LOCK
BOGIE UNLOCK VALVE
LEFT BOGIE TRIM CYLINDER
RIGHT BOGIE TRIM CYLINDER
CHECK VALVE
RELIEF VALVE
RIGHT BOGIE UNLOCK CYLINDER
UNLOCK
PRESSURE
RETURN
UNLOCK LEFT BOGIE
UNLOCK RIGHT BOGIE
NOTE: ILLUSTRATED UNLOCK BOGIE PRESSURES DO NOT OCCUR SIMULTANEOUSLY

BOGIE TRIM AND BOGIE UNLOCK HYDRAULIC SYSTEM FTX80197

Figure 32-97

27. Landing Gear and Brake Limitations

A. Antiskid

Antiskid must be operating for all takeoff and landing operations, except when operating under the limitations of the applicable Hytrol (Antiskid) Inoperative appendices.

B. Air Brake Bottle Pressure Limitations

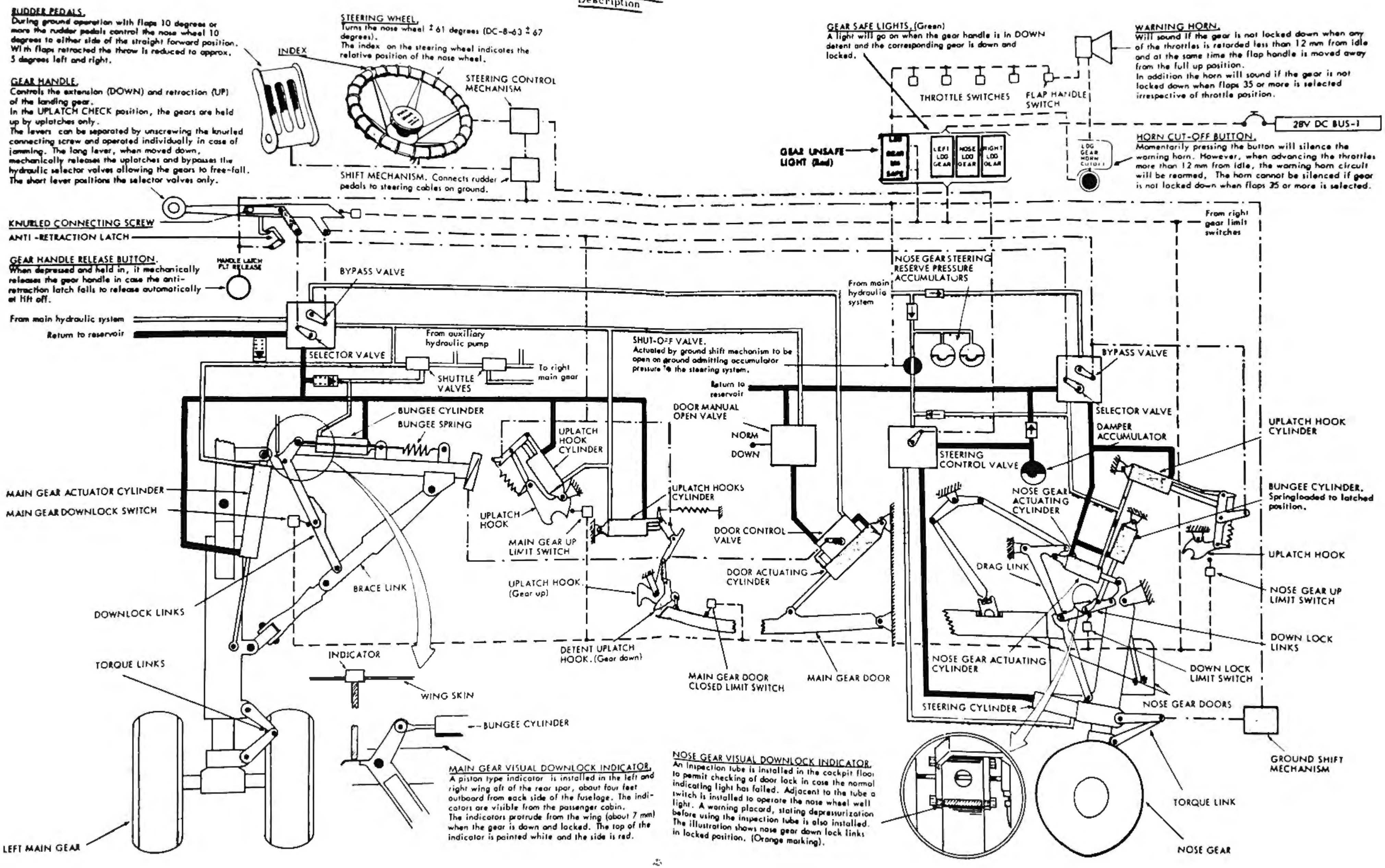
	OAT	**PSI**
Air Brake Pressure	-30° C	2060 to 2420
	-20°	2170 to 2550
	-10°	2270 to 2670
	0°	2360 to 2780
	10°	2460 to 2880
	20°	2540 to 2990
	30°	2630 to 3090

C. Brake Wear Limitations

61/62 Series	1/2 inch
63 Series	7/8 inch

D. Maximum Tire Ground Speed Limitations

DC-8-62/63	195 knots (225 mph)



RUDDER PEDALS.
During ground operation with flaps 10 degrees or more the rudder pedals control the nose wheel 10 degrees to either side of the straight forward position. With flaps retracted the throw is reduced to approx. 5 degrees left and right.

GEAR HANDLE.
Controls the extension (DOWN) and retraction (UP) of the landing gear.
In the UPLATCH CHECK position, the gears are held up by uplatches only.
The levers can be separated by unscrewing the knurled connecting screw and operated individually in case of jamming. The long lever, when moved down, mechanically releases the uplatches and bypasses the hydraulic selector valves allowing the gears to free-fall. The short lever positions the selector valves only.

STEERING WHEEL.
Turns the nose wheel ± 61 degrees (DC-8-63 ± 67 degrees).
The index on the steering wheel indicates the relative position of the nose wheel.

SHIFT MECHANISM. Connects rudder pedals to steering cables on ground.

GEAR SAFE LIGHTS. (Green)
A light will go on when the gear handle is in DOWN detent and the corresponding gear is down and locked.

WARNING HORN.
Will sound if the gear is not locked down when any of the throttles is retarded less than 12 mm from idle and at the same time the flap handle is moved away from the full up position.
In addition the horn will sound if the gear is not locked down when flaps 35 or more is selected irrespective of throttle position.

HORN CUT-OFF BUTTON.
Momentarily pressing the button will silence the warning horn. However, when advancing the throttles more than 12 mm from idle, the warning horn circuit will be rearmed. The horn cannot be silenced if gear is not locked down when flaps 35 or more is selected.

GEAR HANDLE RELEASE BUTTON.
When depressed and held in, it mechanically releases the gear handle in case the anti-retraction latch fails to release automatically at lift off.

SHUT-OFF VALVE.
Actuated by ground shift mechanism to be open on ground admitting accumulator pressure to the steering system.

MAIN GEAR VISUAL DOWNLOCK INDICATOR.
A piston type indicator is installed in the left and right wing aft of the rear spar, about four feet outboard from each side of the fuselage. The indicators are visible from the passenger cabin.
The indicators protrude from the wing (about 7 mm) when the gear is down and locked. The top of the indicator is painted white and the side is red.

NOSE GEAR VISUAL DOWNLOCK INDICATOR.
An inspection tube is installed in the cockpit floor to permit checking of door lock in case the normal indicating light has failed. Adjacent to the tube a switch is installed to operate the nose wheel well light. A warning placard, stating depressurization before using the inspection tube is also installed. The illustration shows nose gear down lock links in locked position. (Orange marking).